Hake MSE: process, simulation model structure, and conditioning

JMC meeting

Aug 2019

Kristin Marshall – NOAA NWFSC MSE Coordinator

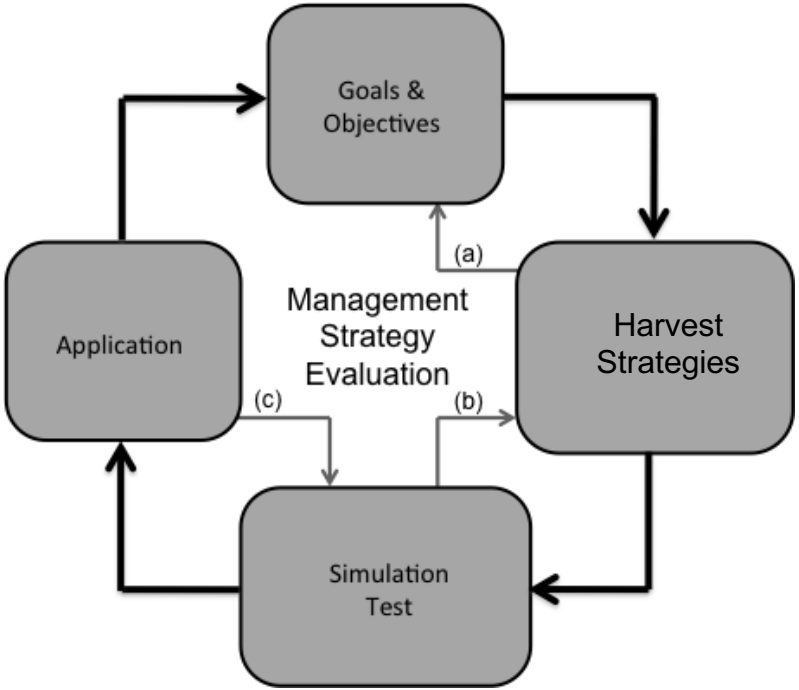
on behalf of the MSE analyst team

Outline

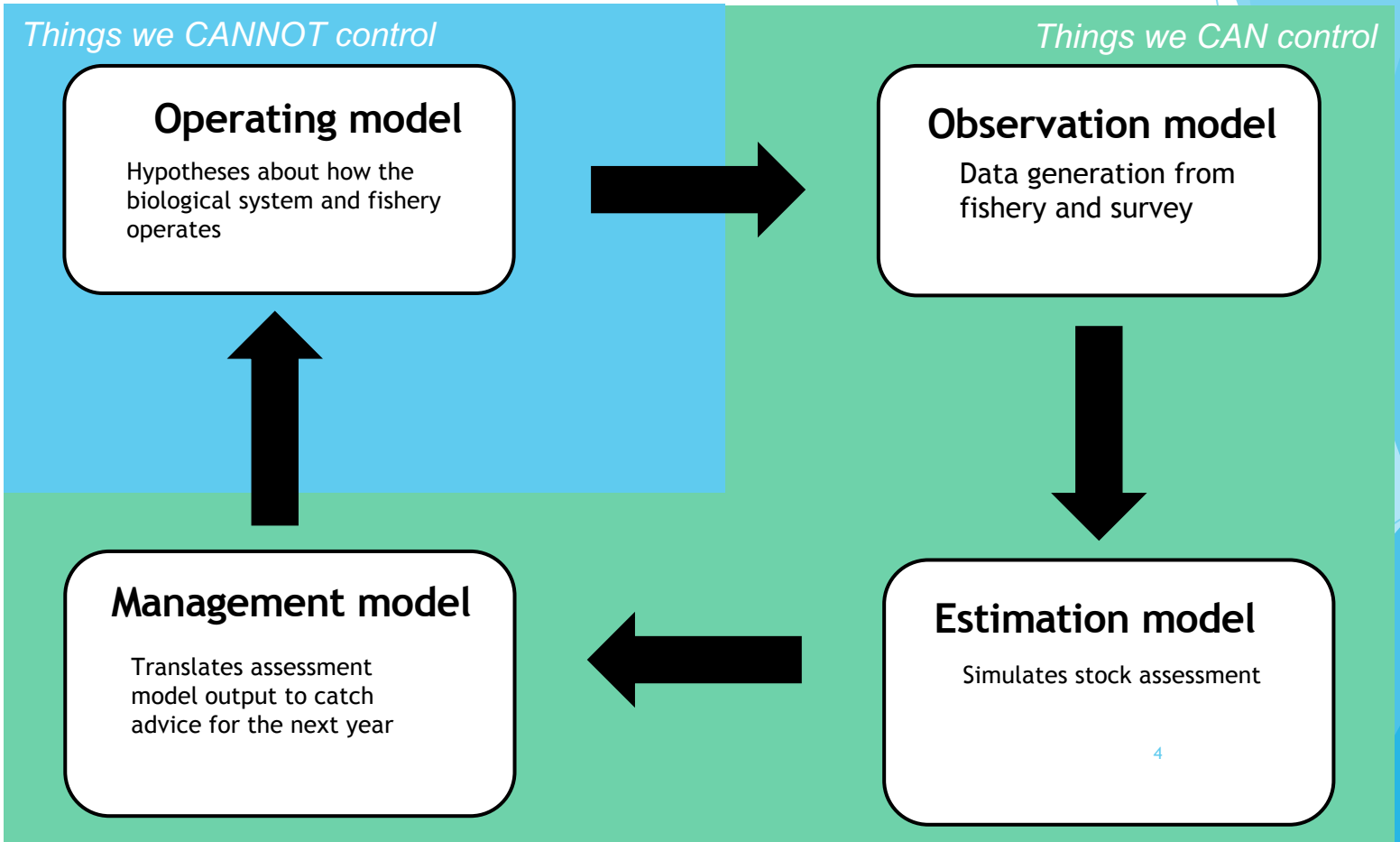
- Work plan and timeline
- MSE simulation model structure
- Conditioning

MSE is a collaborative, iterative process

- Setting goals, objectives and performance metrics
- Choosing harvest strategies to test
- Closed-loop simulation testing
- Application of information gained from simulation results to future management decisions
- Communication throughout the process is key



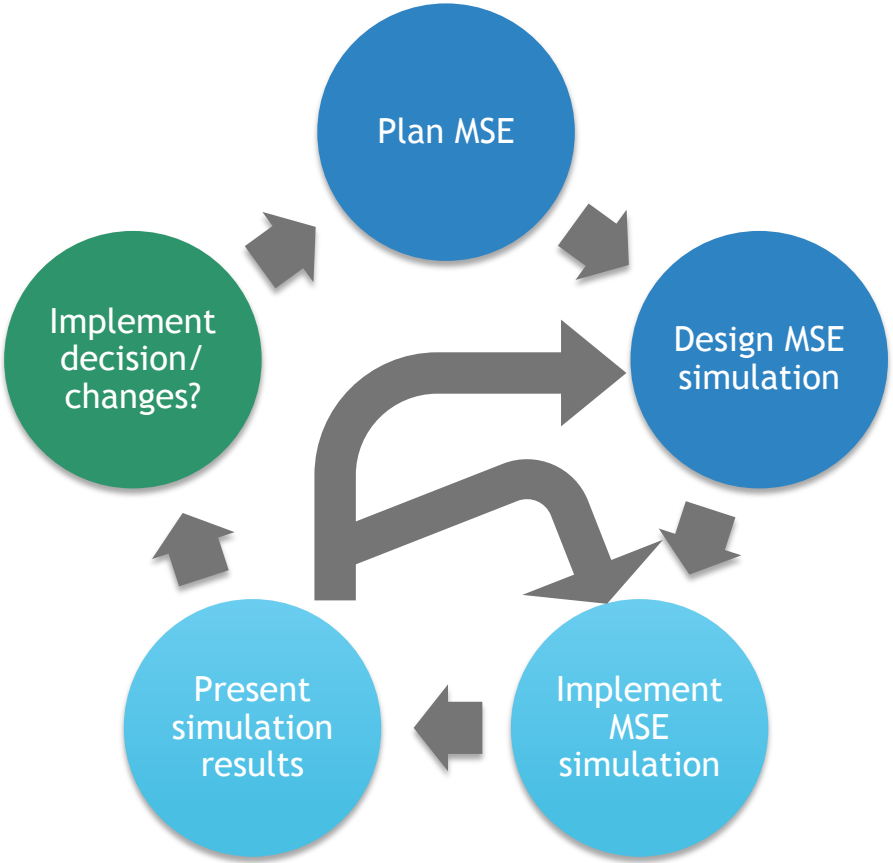
Generalized closed-loop simulation model for MSE



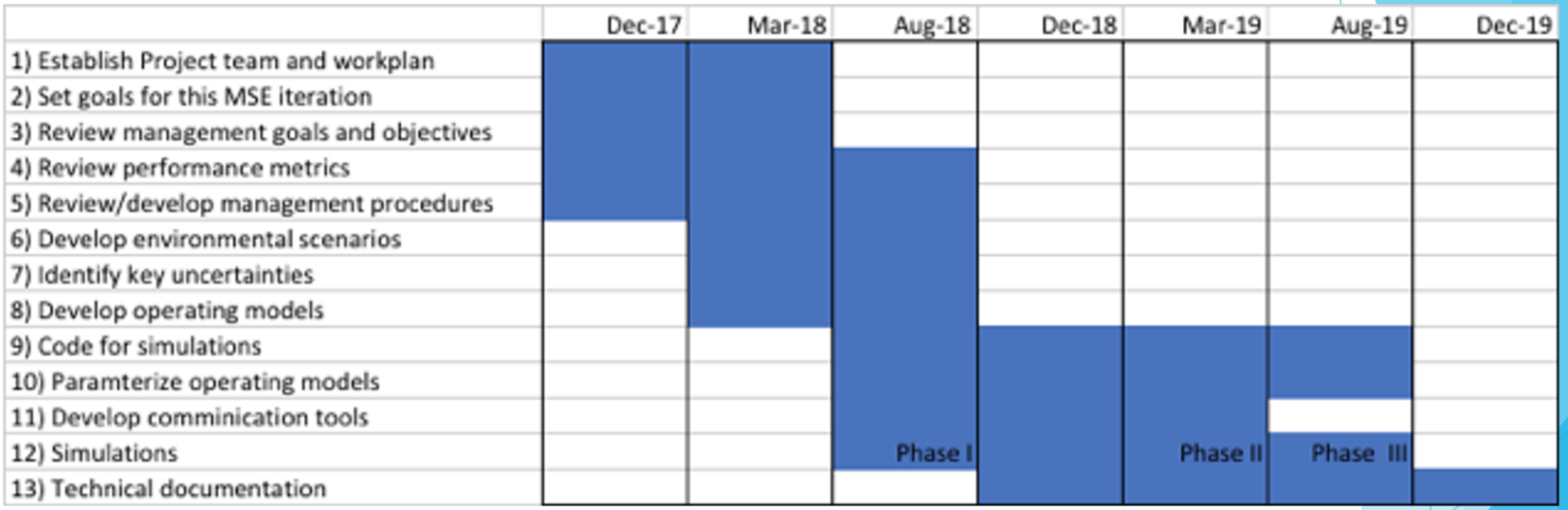
Reminder: MSE is meant to improve strategic decision making

- Testing the performance of harvest strategies (e.g, data collection, assessment, decision rule) against pre-specified objectives over:
  - Many replicate “futures”
  - Scenarios capturing “things we can’t control”, e.g. changes in productivity, recruitment, natural mortality, spatial distribution
  - Alternative hypotheses about how the fishery system functions
- MSE is not meant to inform tactical decision-making

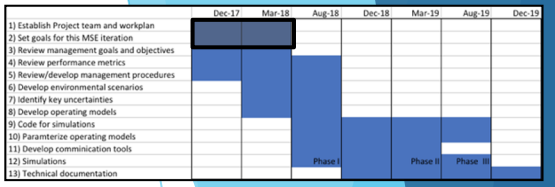
Review of work plan and timeline


Plan MSE
Design MSE simulation
Implement MSE simulation
Present simulation results
Implement decision/ changes?

Overview timeline for MSE tasks

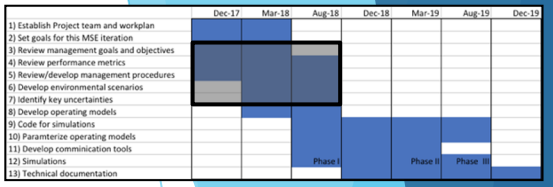


Plan and Design I



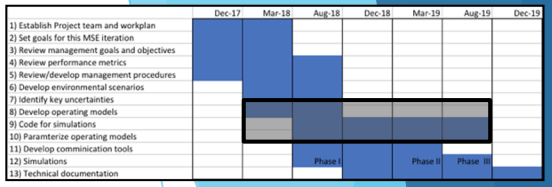
1. **Establish project team and MSE Work group, roles and responsibilities, communication strategies, work plan**
2. **Establish goals for this iteration of the MSE (What problem are we trying to address?)**
   - **JMC's stated MSE goals (March 2018):**
     - Evaluate the performance of current hake harvest strategy under alternative hypotheses about current and future environmental conditions
     - Better understand the effects of hake distribution and movement on both countries' ability to catch fish
     - Better understand how fishing in each country affects the availability of fish to the other country in future years

Plan and Design II



3. Review goals and objectives of managers with feedback from MSE working group (iterative process)
4. Review performance metrics with feedback from MSE working group (iterative process)
5. Decide/develop harvest strategies to test
6. Develop environmental scenarios
7. Identify other types of scenarios (?)
8. Develop operating and estimation models

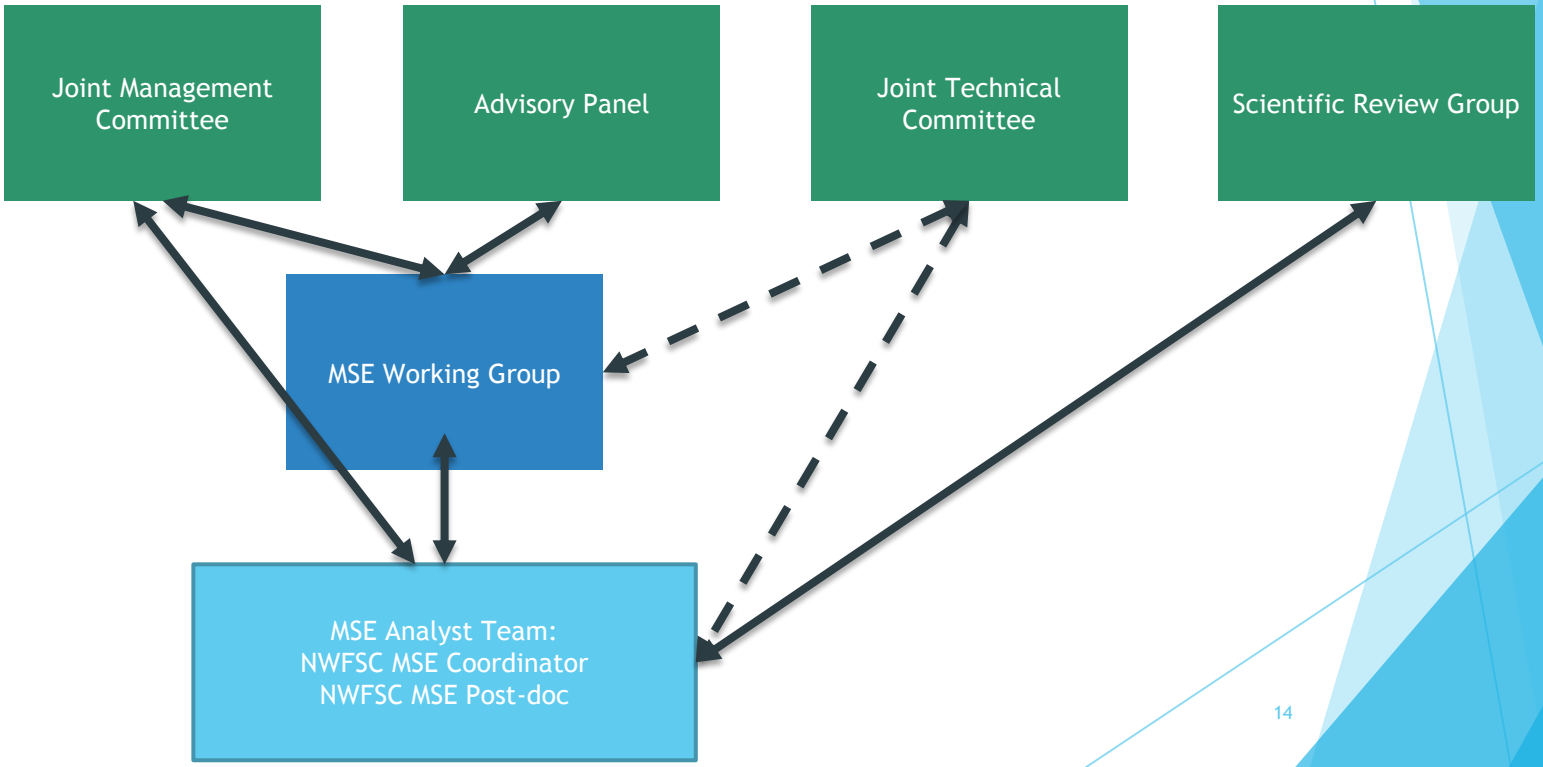
Implement MSE simulation



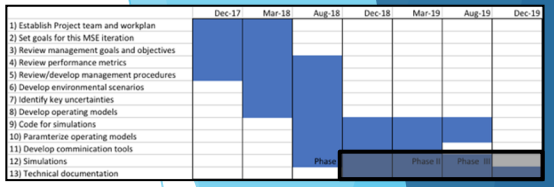
9. Develop computer code for closed loop simulation
10. Parameterize operating models
11. Develop communication tools for simulation results

11. Develop communication tools

- Communication plan – is this structure meeting the needs of management bodies and interested parties?

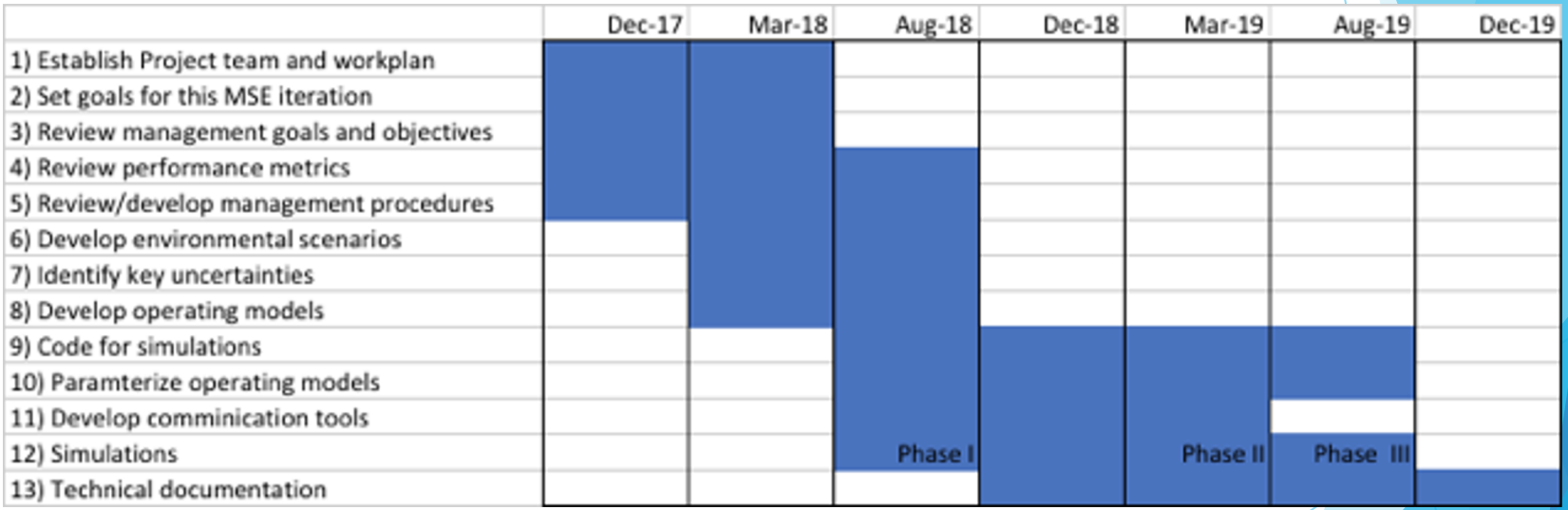


Provide results of MSE simulation



12. Present simulation results
    - Deliverables:
        - First iteration, with a single non-conditioned model –JMC summer meeting 2018
        - Second iteration, with at least one conditioned model – Feb/March 2019
        - Third iteration, with multiple conditioned models – Aug 2019
13. Technical documentation for SRG review in Feb 2020

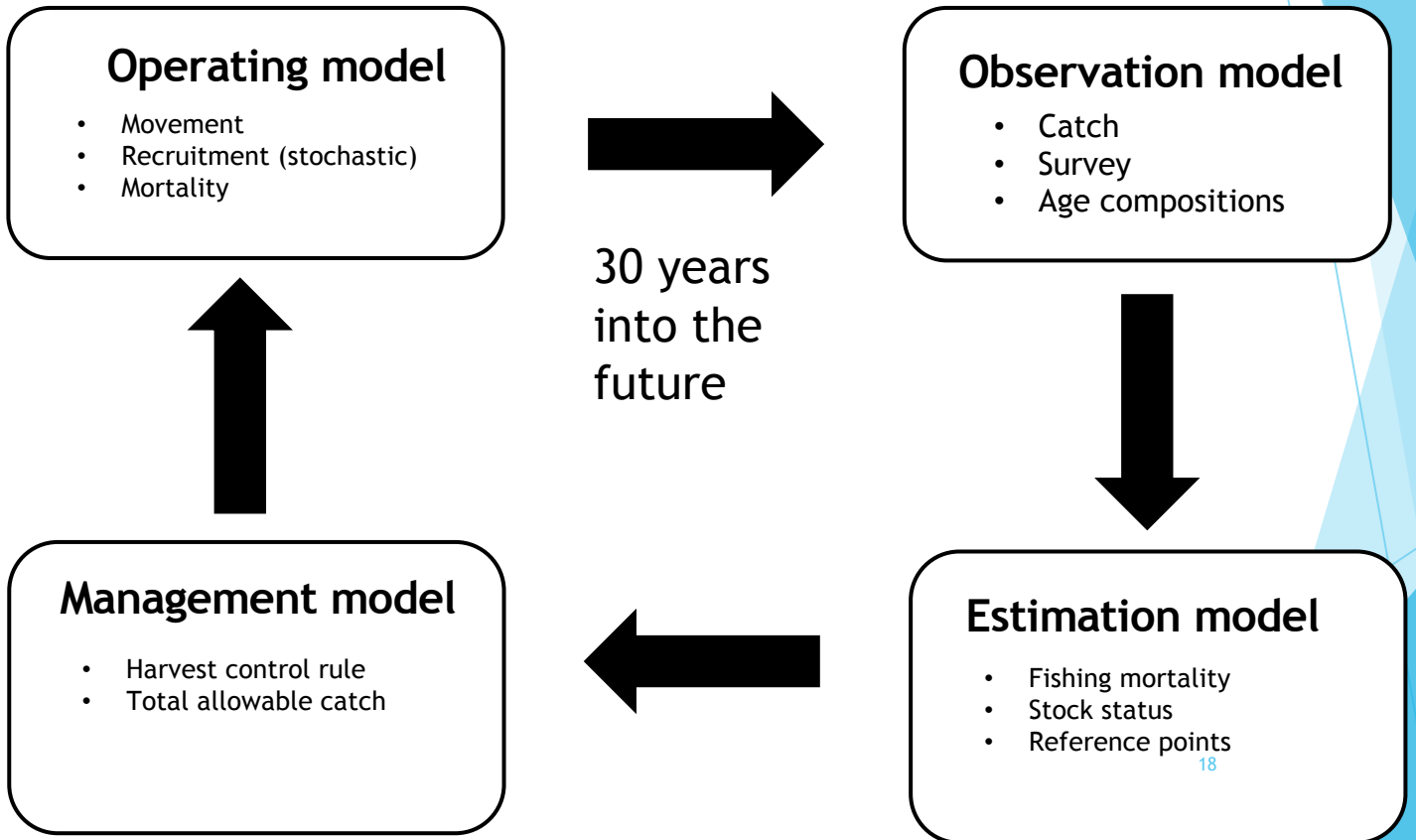
Next steps



Iterative process

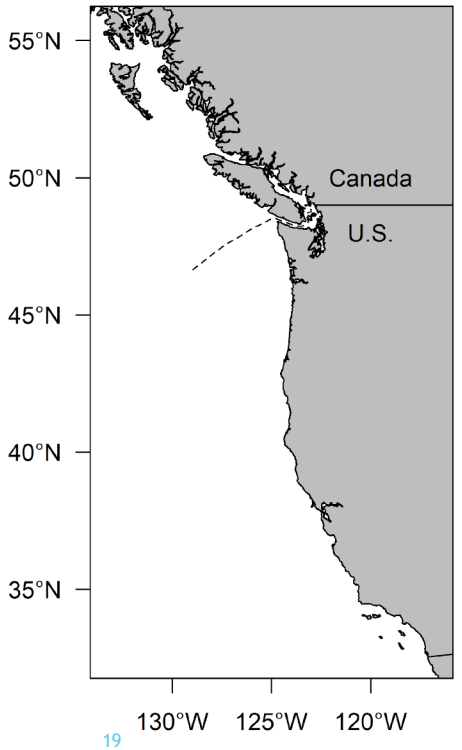
Simulation model structure

Conceptual Pacific hake MSE simulation framework



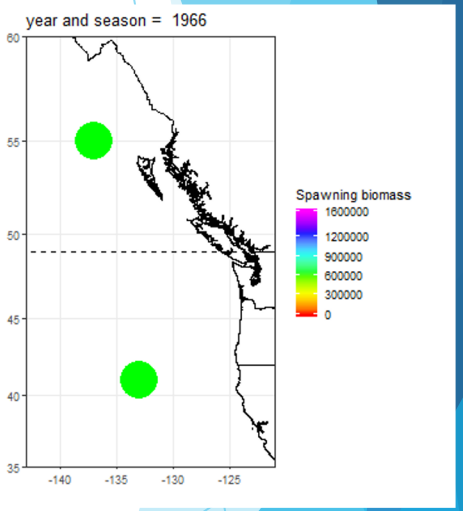
Operating model

- Age-structured model
- Time-step is quarterly (four seasons per year)
- Spatially explicit fish movement, spawning, selectivity, catch
- Movement happens in every season
- Spawning occurs in season 1
- Written in a flexible framework to allow exploration of different scenarios and OM configurations
- Conditioned upon available data from survey and fishery



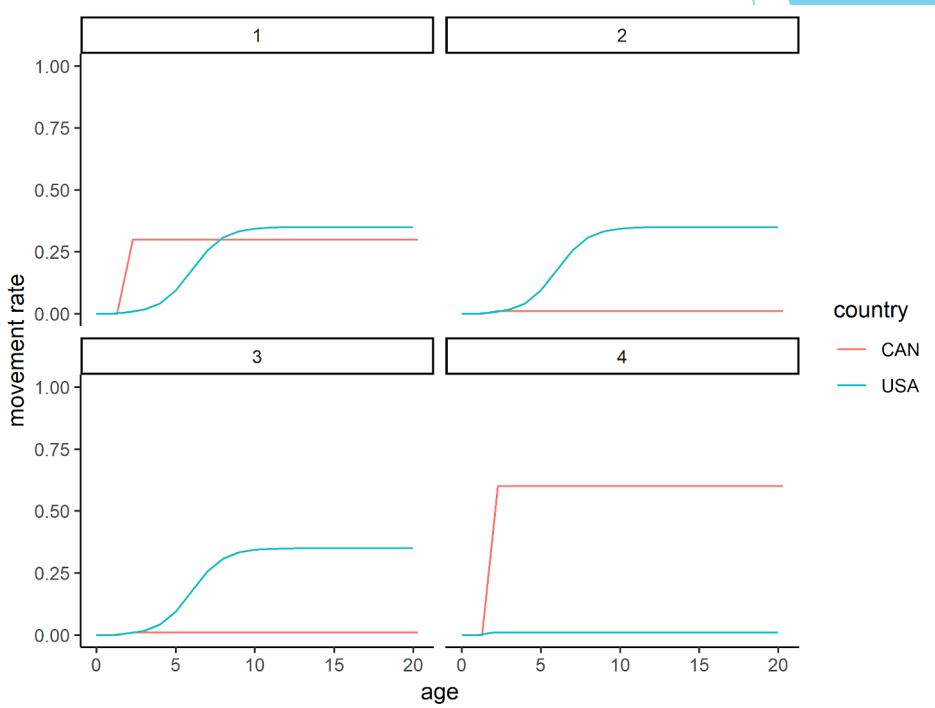
Movement

- Modeled as a fraction of the age group that moves out of an area
- Older individuals have a greater probability to move than smaller ones
- Most spawners move south in the last season of the year to spawn
- Currently implemented as 2 boxes (US and Canadian waters)



Movement increases with age and varies by season

$$\omega_a = \frac{\kappa_i}{1 + e^{-\gamma a - a_{50}}}$$



κ is the maximum movement rate

Spawning

- Beverton Holt with annual recruitment deviations
- Spawning occurs in the beginning of season one
- Stock recruitment relationship is area-specific (depends on the spawners in each area) – deviations are the same for all areas
- Recruits (0-1 year) do not move

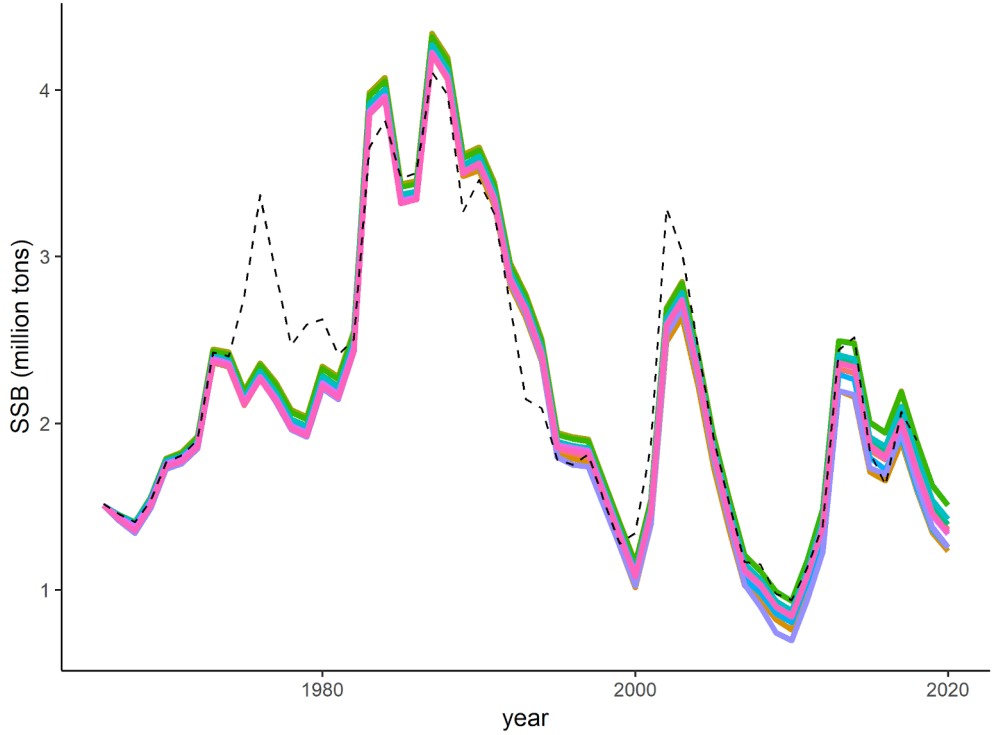
Photo credit Pete Frey (NWFSC)

Fisheries

- Catch is divided by areas according to the Treaty
- The operating model calculates the fishing mortality in each area depending on the catch distribution per season
- Selectivity can be area specific or constant (baseline)
- Catches occur predominantly in season 2 and 3

Conditioning the operating model

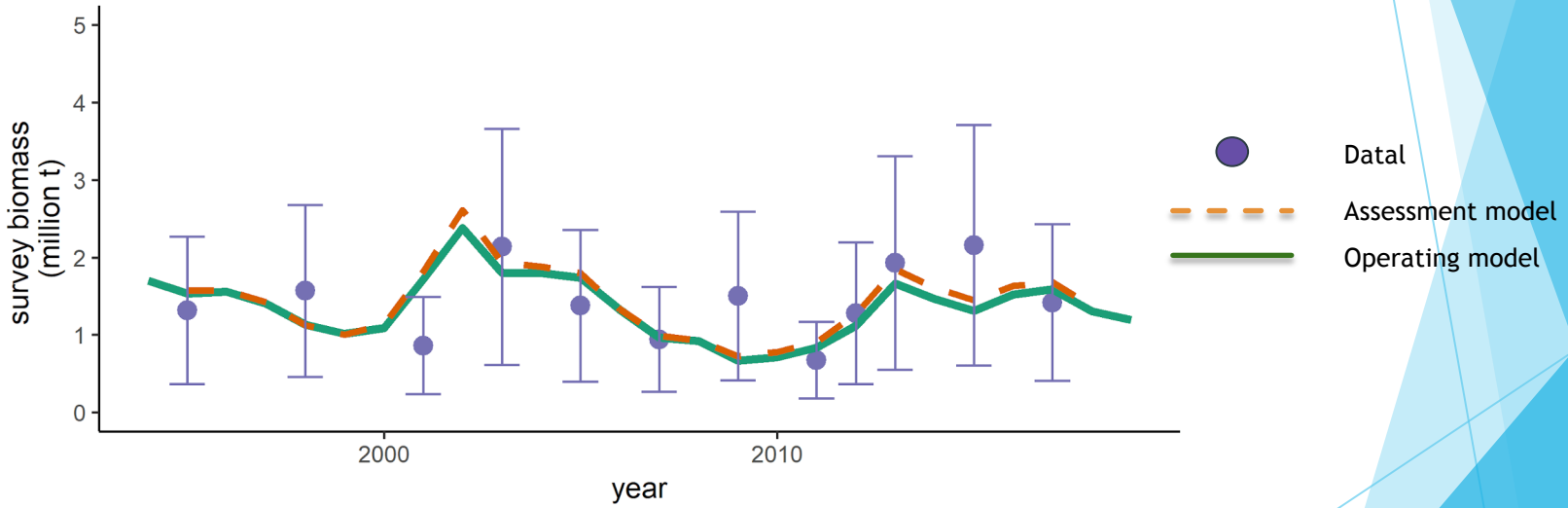
Spawning biomass with varying movement parameters



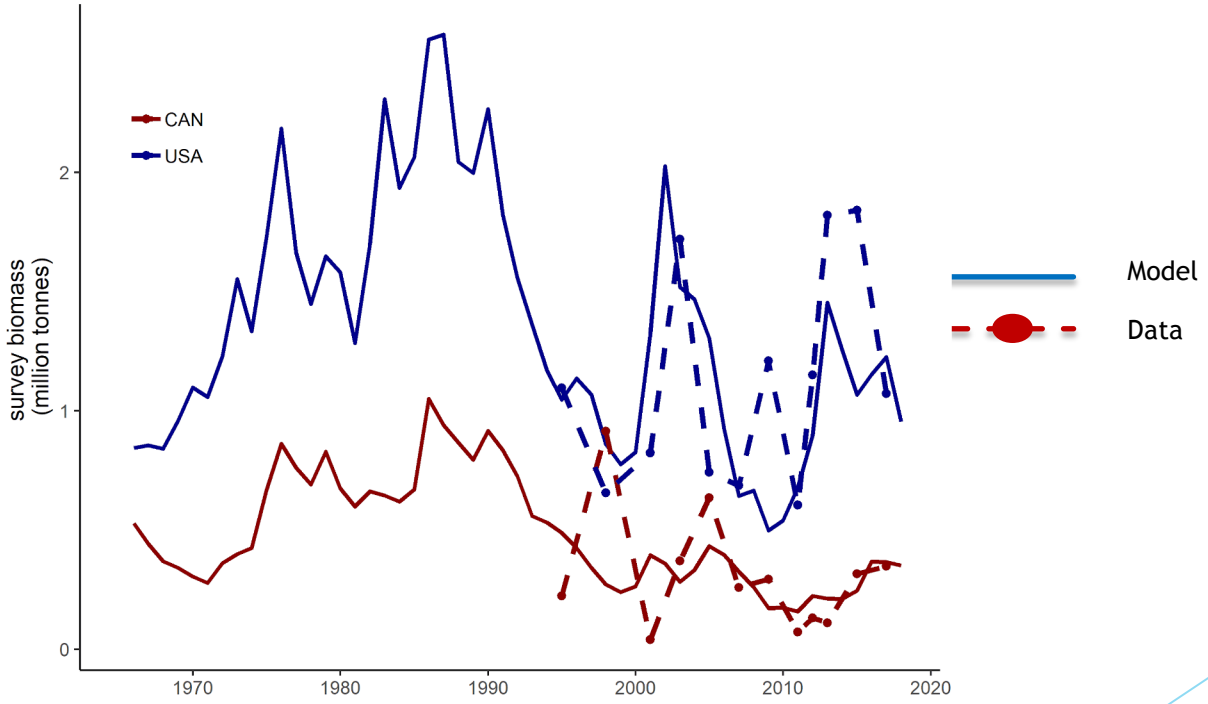
Conditioning update since March

- Updated conditioned model to include 2018 data
- Minor changes in how movement and mortality works, to better fit SS3
- Differentiated selectivity in Canada and the US
- Updated bias adjustment in forecast model
- Forecast model now calculates a realized catch (75% of what is available in a season), if the total allocated catch is not available
- Added additional functionality in code to run a range of MSE scenarios

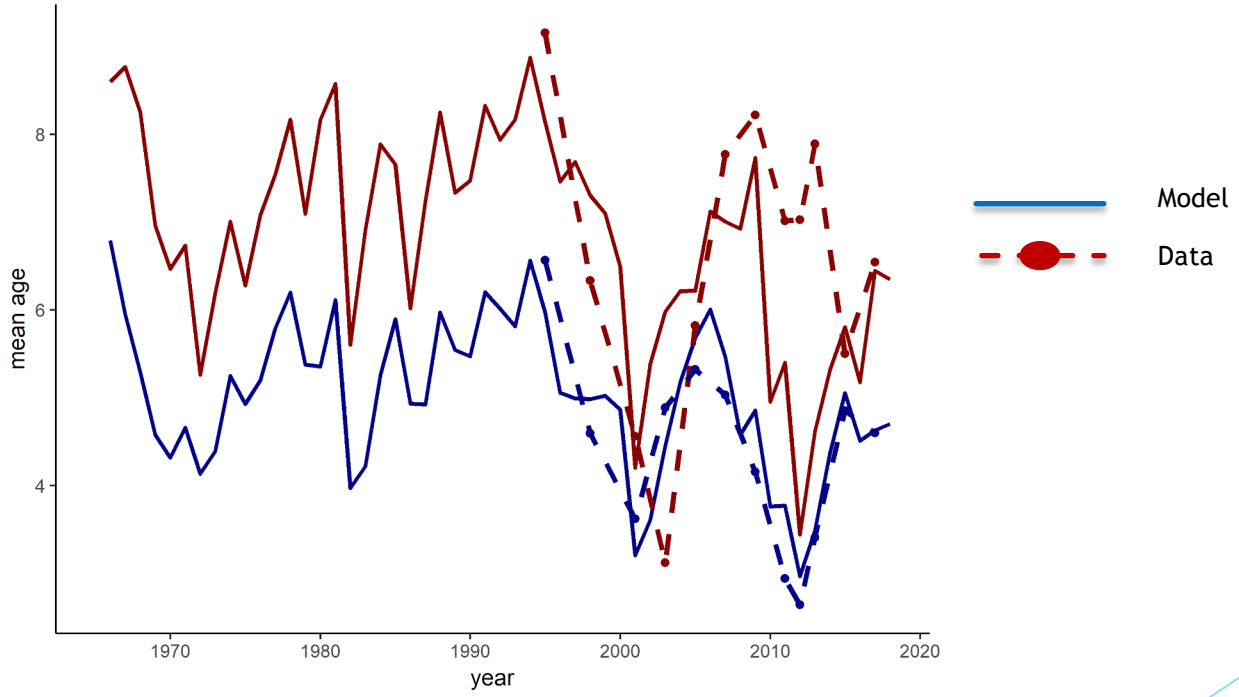
Biomass observed in survey



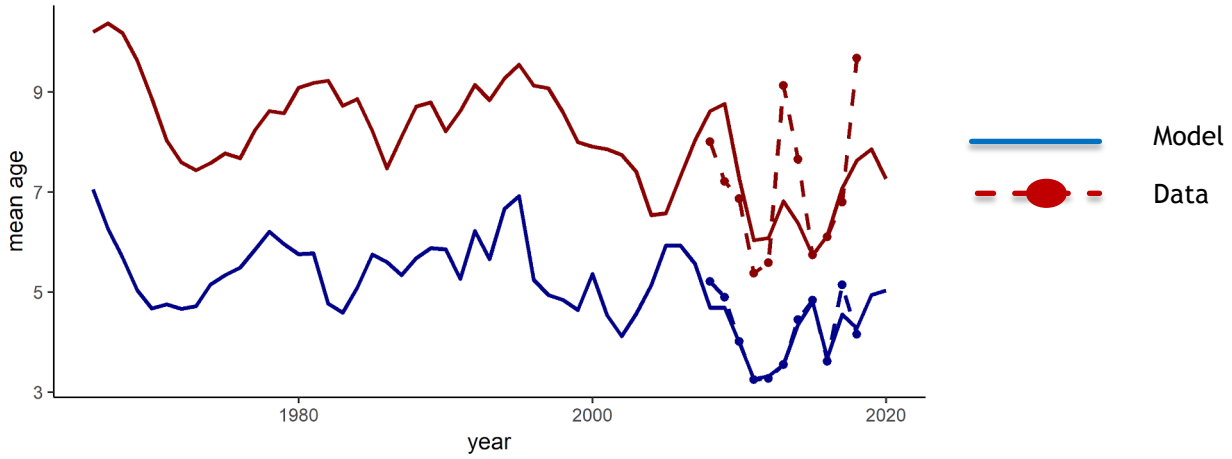
Survey biomass in Canada and USA



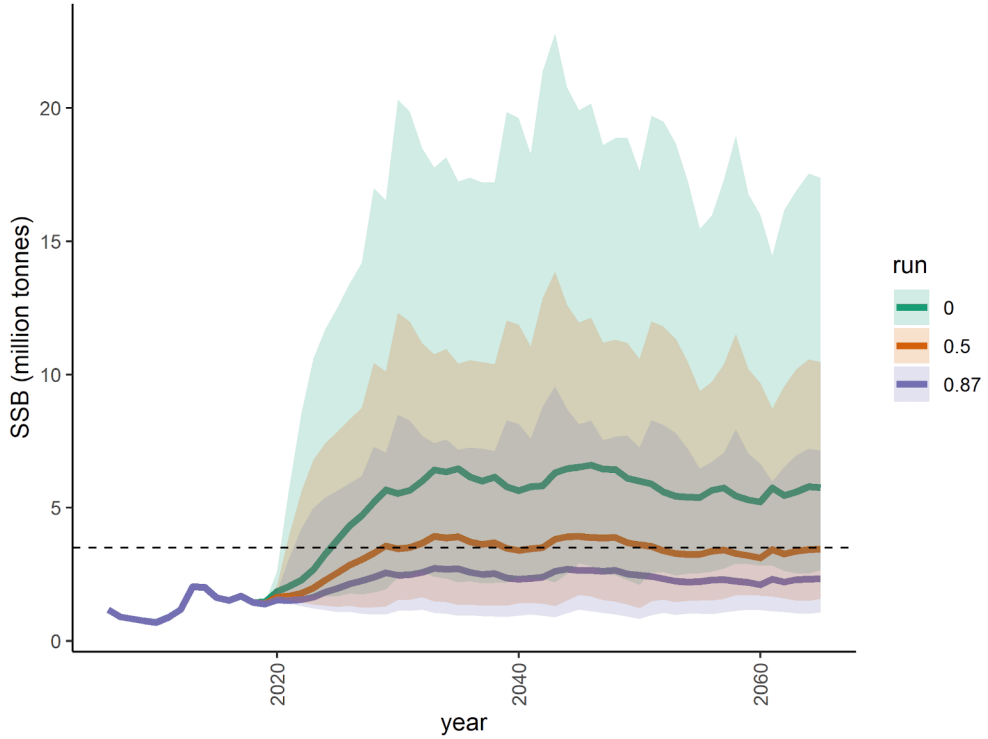
Average age in the survey



Average age in catch



Adjusting the scale of the population



A management strategy evaluation of Pacific hake: scenarios and results

Nis S. Jacobsen, Aaron M. Berger, Kristin N. Marshall, Ian G. Taylor

Scenarios

- 5 different scenarios through the full MSE

1. Catch scenarios
2. Movement scenarios (not shown)
3. Selectivity scenarios
4. Climate change (movement increases over time)
5. Survey frequency scenarios

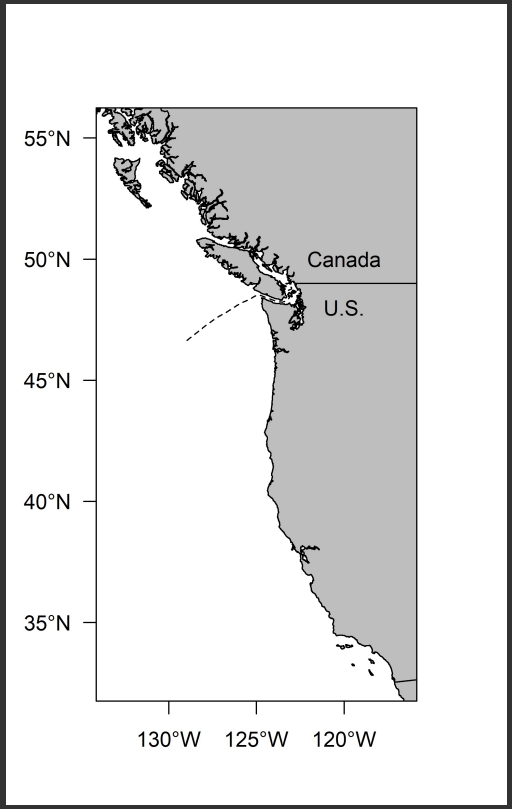
Management objectives identified by MSE working group

Coastwide objectives

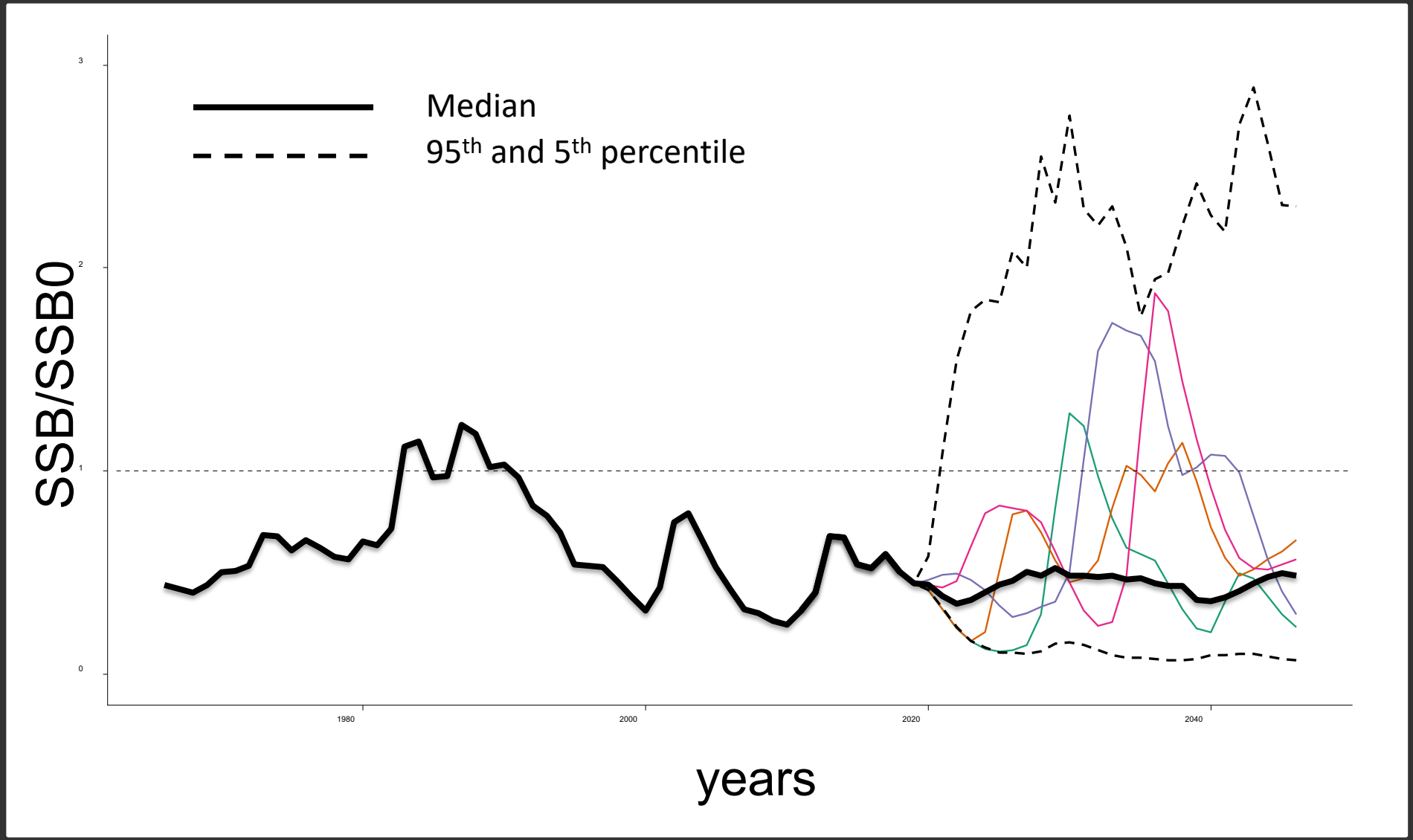
- Minimize risk of severe overfishing and closing the fishery
- Minimize the risk of spawning biomass dropping below the specified management target for >3 years
- Avoid closing the fishery
- Avoid high variability in total catches
- Given above, maintain high average coast wide catch

Spatial objectives

- Maintain enough biomass to allow TAC to be attained in both countries



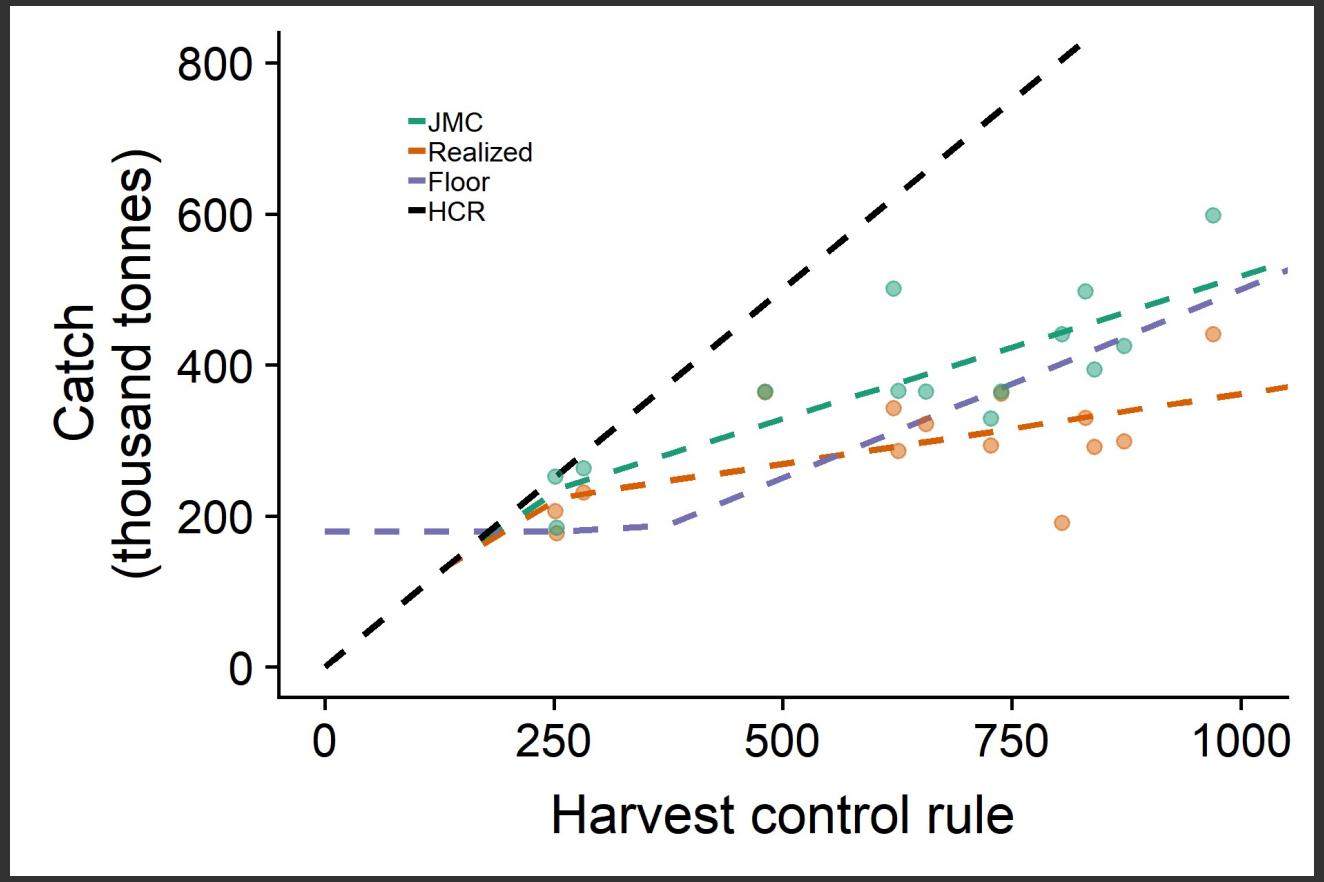
How are the data presented



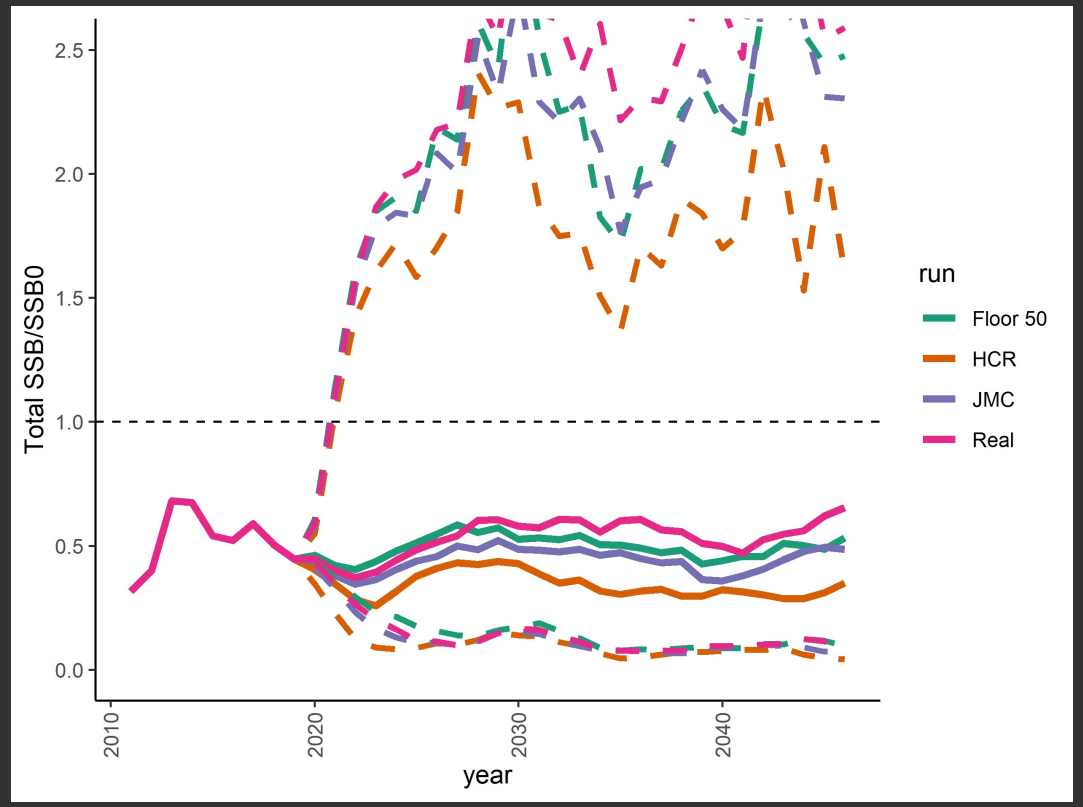
CATCH SCENARIOS

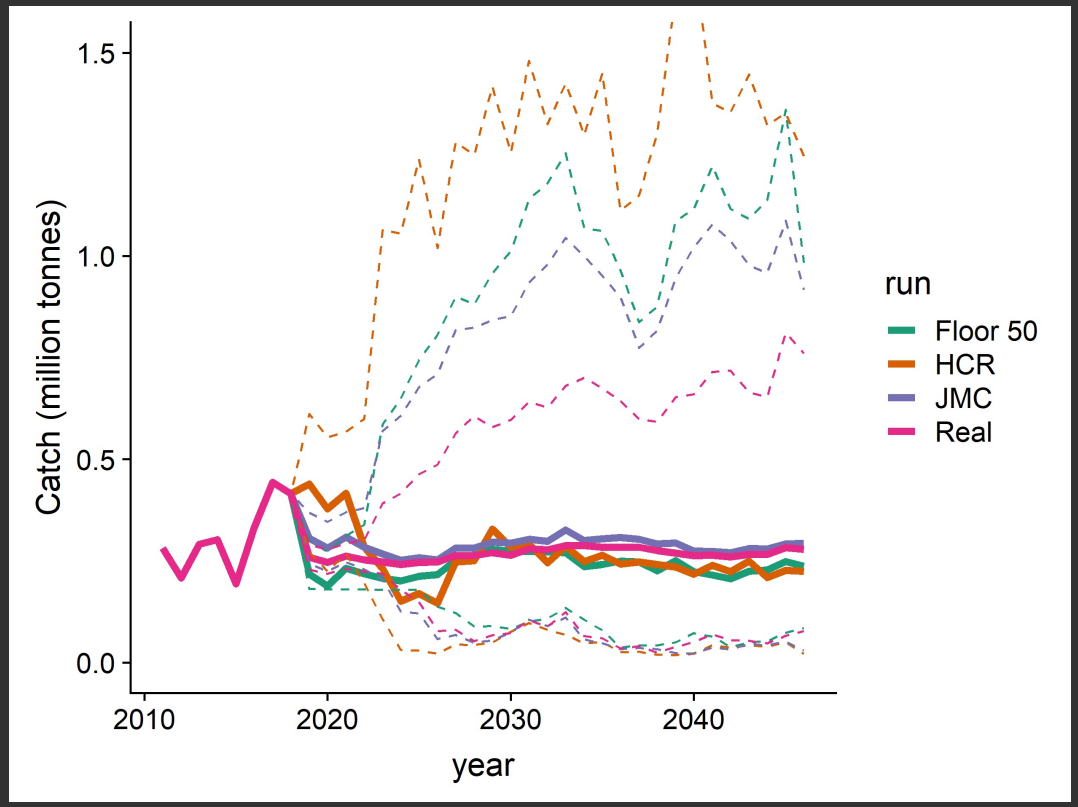
Catch scenarios

- Standard HCR
- Catch adjusted by historical JMC recommendation
- Catch adjusted by historical realized catch
- 50% HCR, but with a floor of 180000tonnes

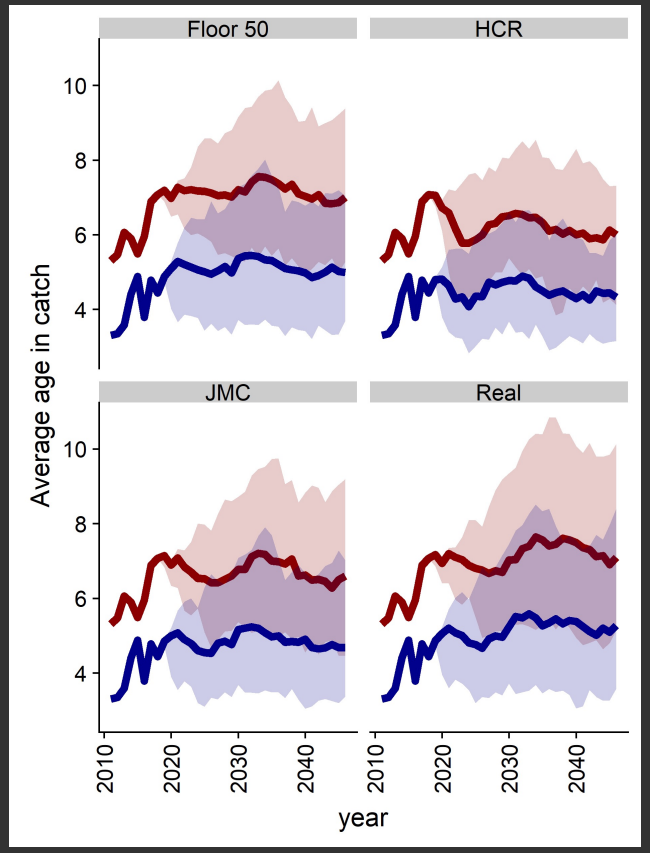


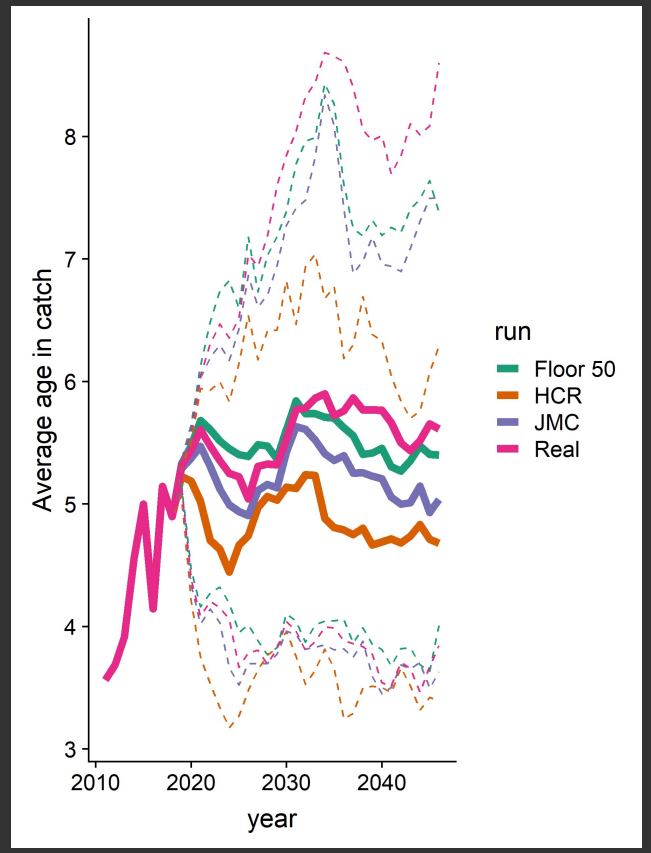
Total catches and biomass





Age composition in the catch

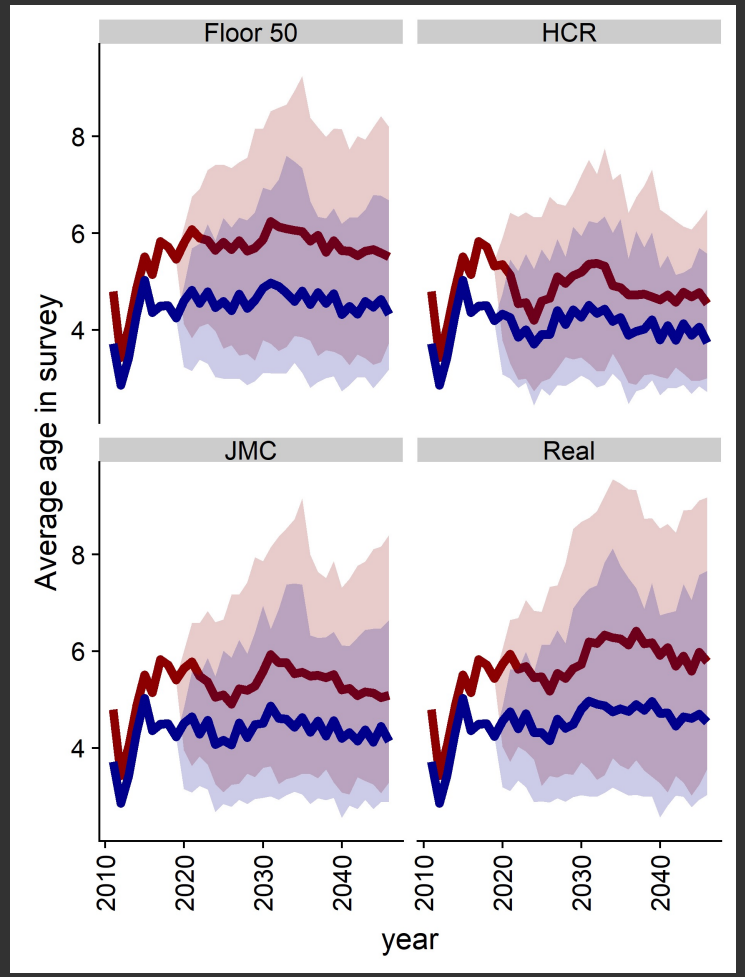


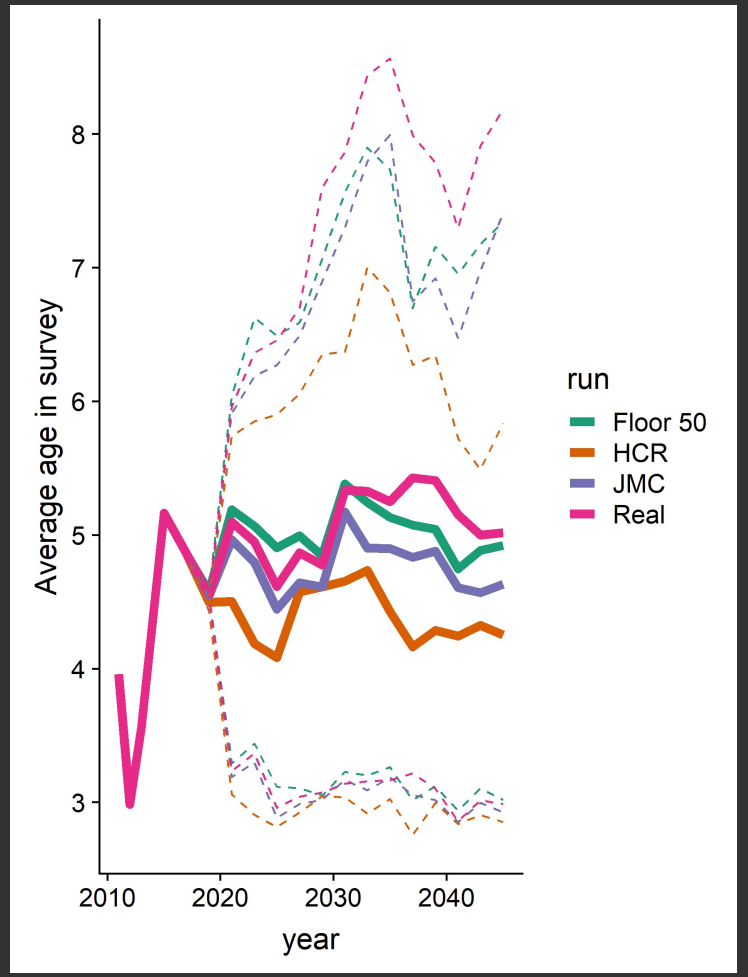


Canada

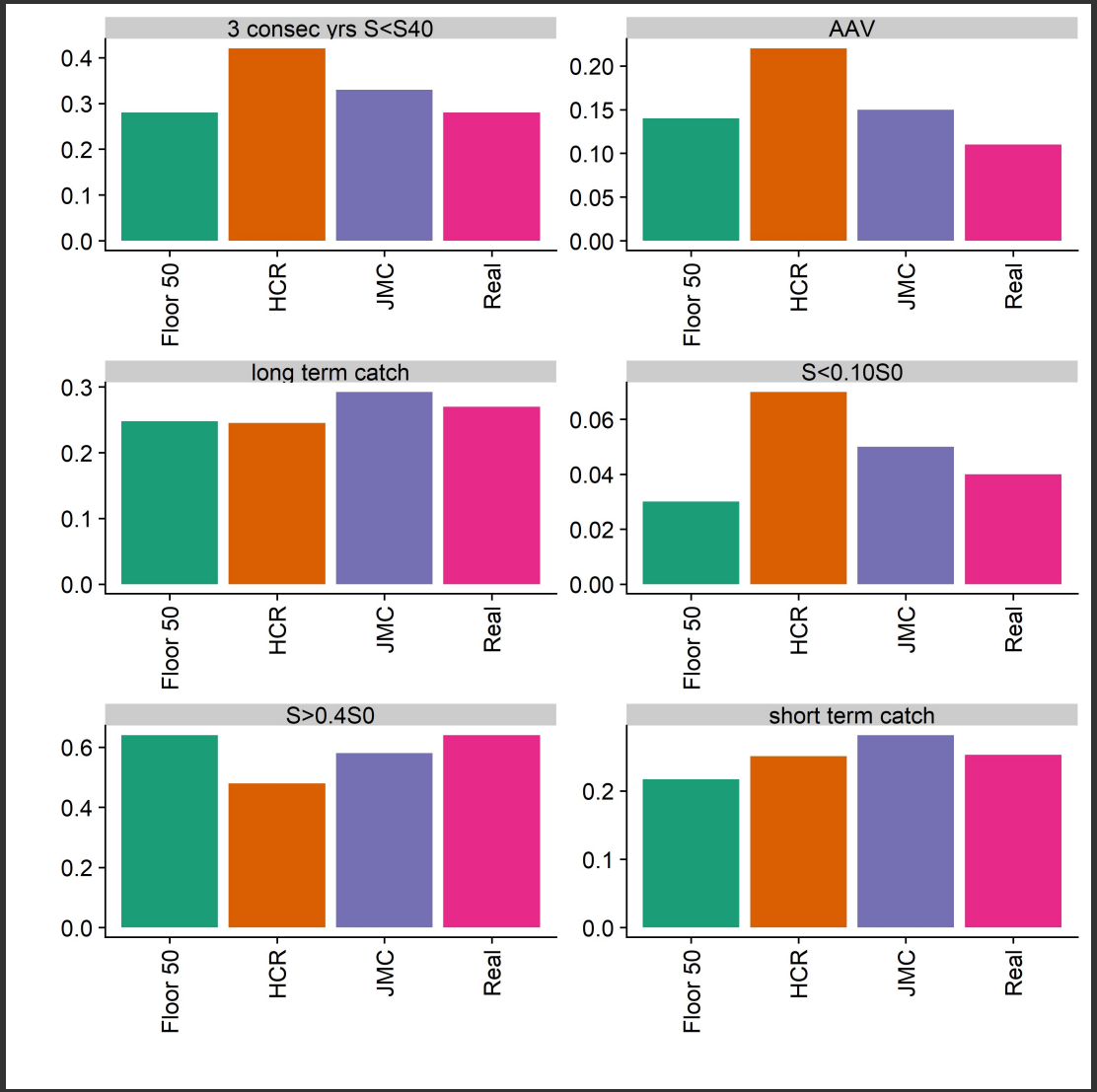
USA

Age composition between the countries





Performance metrics for catch scenarios



Catch scenarios conclusions

- The standard HCR performs worse than the realized and JMC scenarios in almost all cases
- It provides both lower catch and worse status of the stock
- Half of the HCR with a floor of 180k performs similar to the realized catch scenario

SELECTIVITY

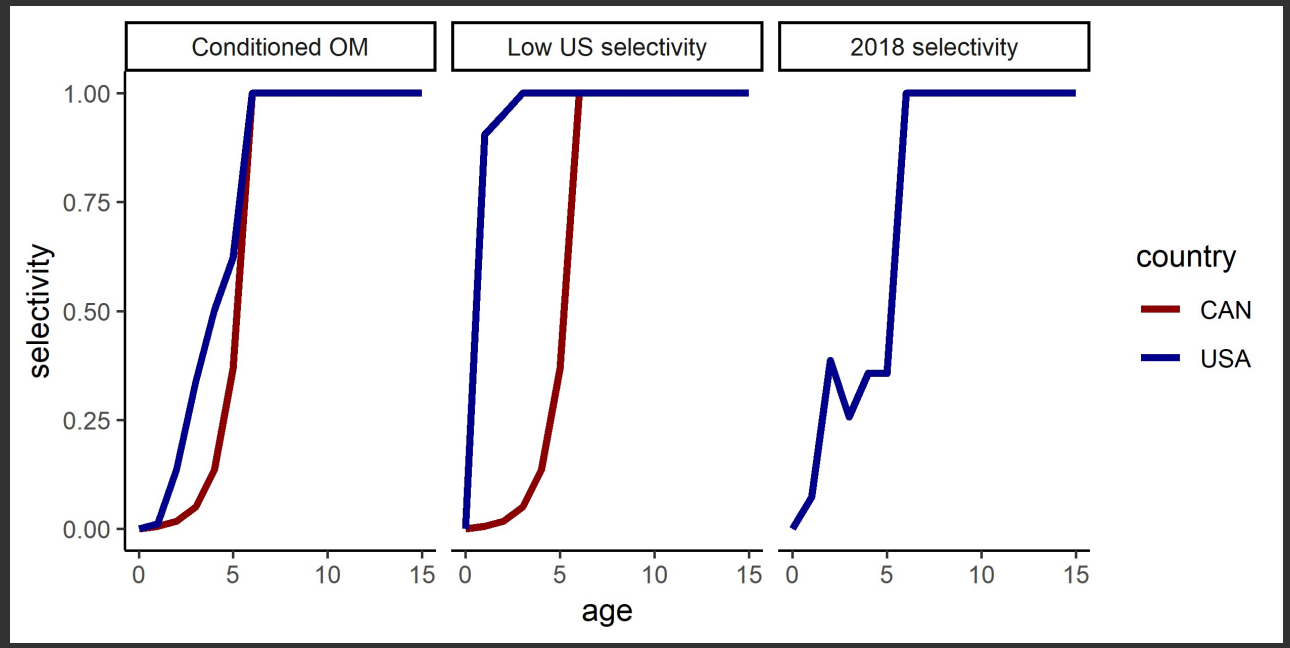
Selectivity

- 3 selectivities (constant in time)

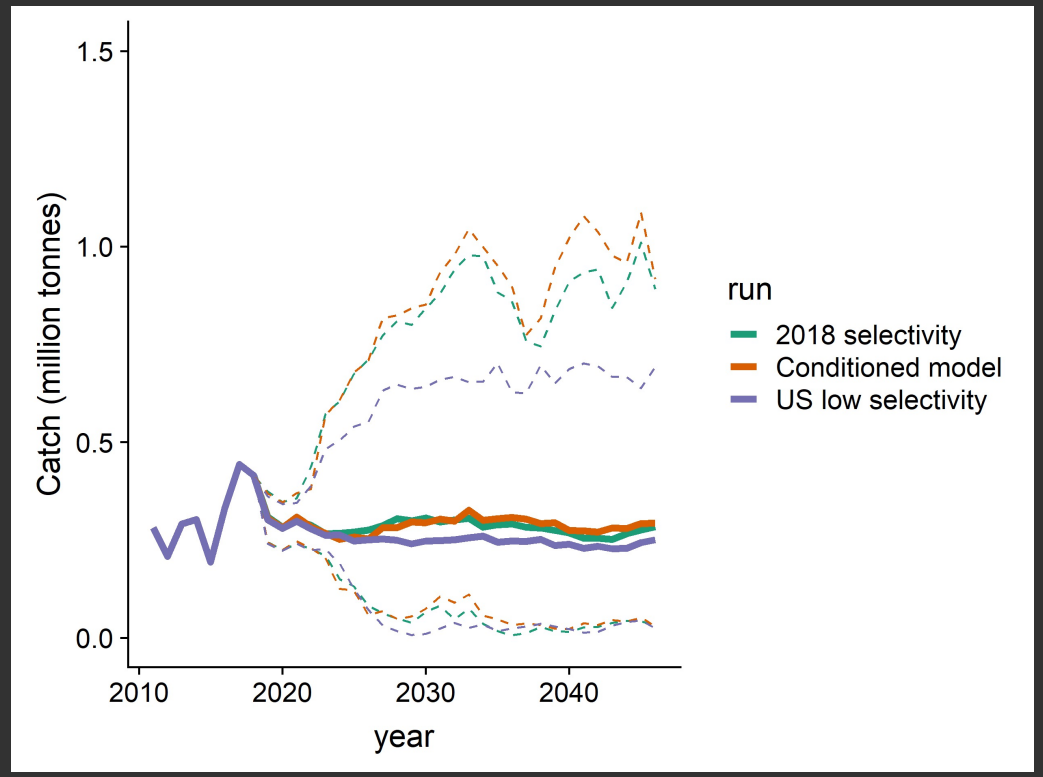
1. The selectivity from the conditioned operating model

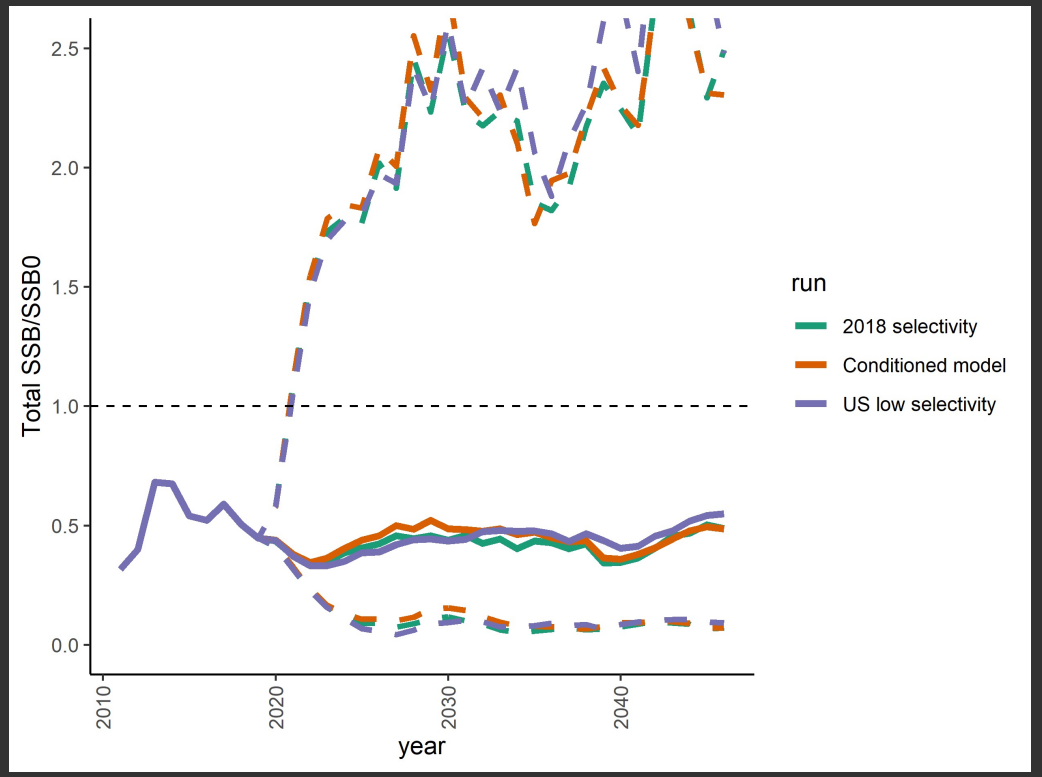
2. US targets small fish – Canada has the same as in the conditioned operating model

3. Selectivity is the same in the two countries



Catch


Catch (million tonnes)
1.5
1.0
0.5
0.0
2010
2020
2030
2040
year
run
2018 selectivity
Conditioned model
US low selectivity


Total SSB/SSB0
2.5
2.0
1.5
1.0
0.5
0.0
2010
2020
2030
2040
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run
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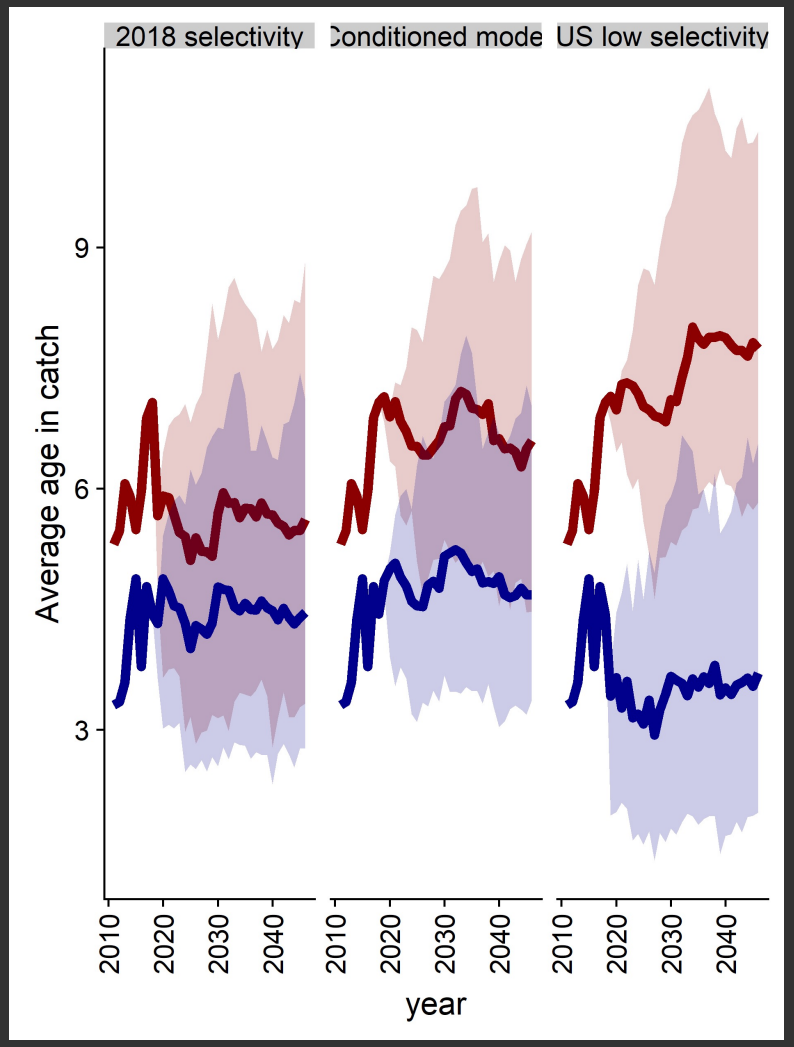
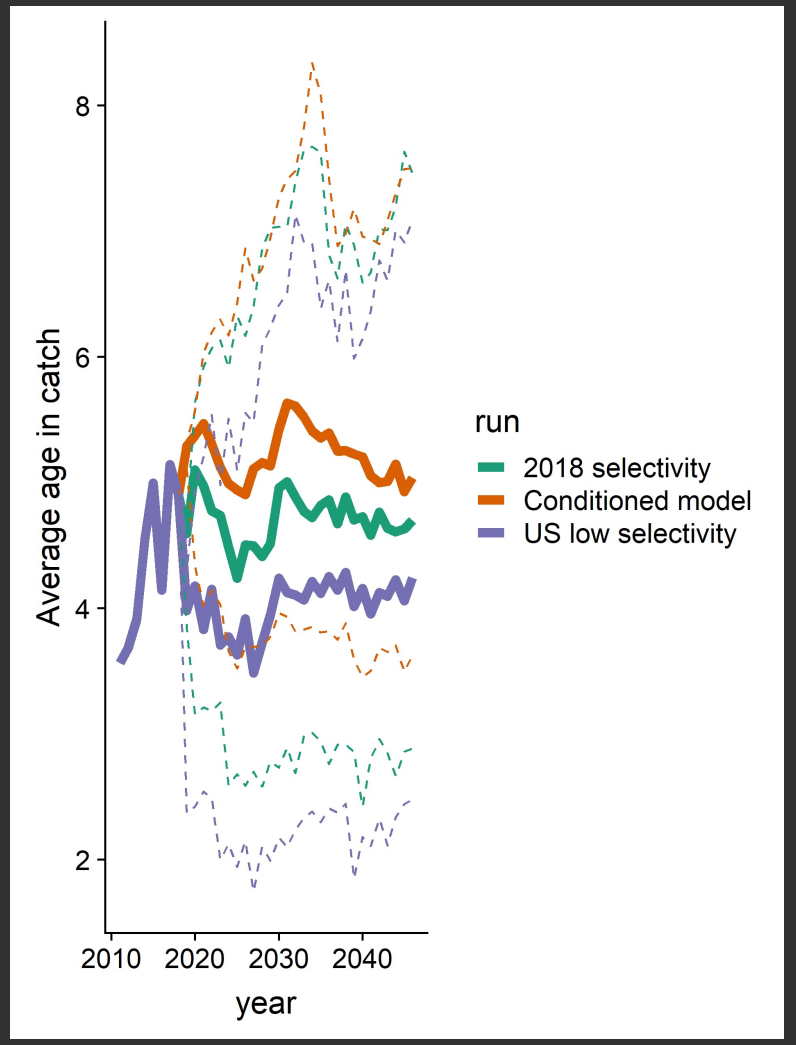
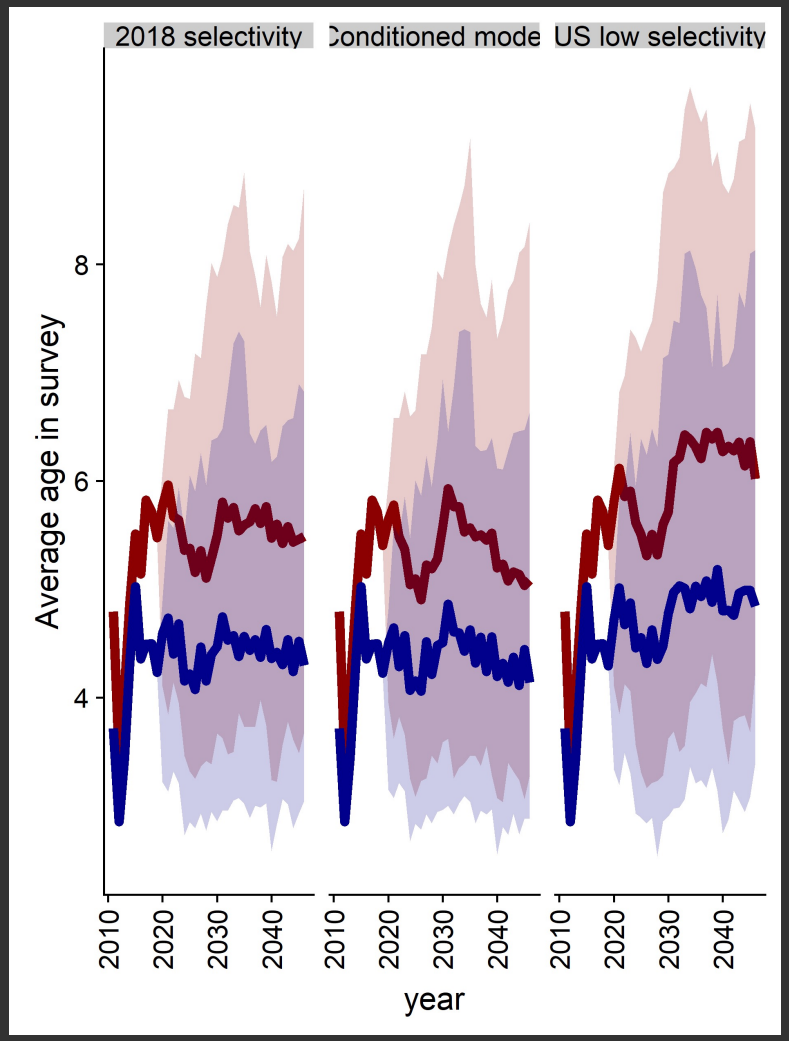
US low selectivity

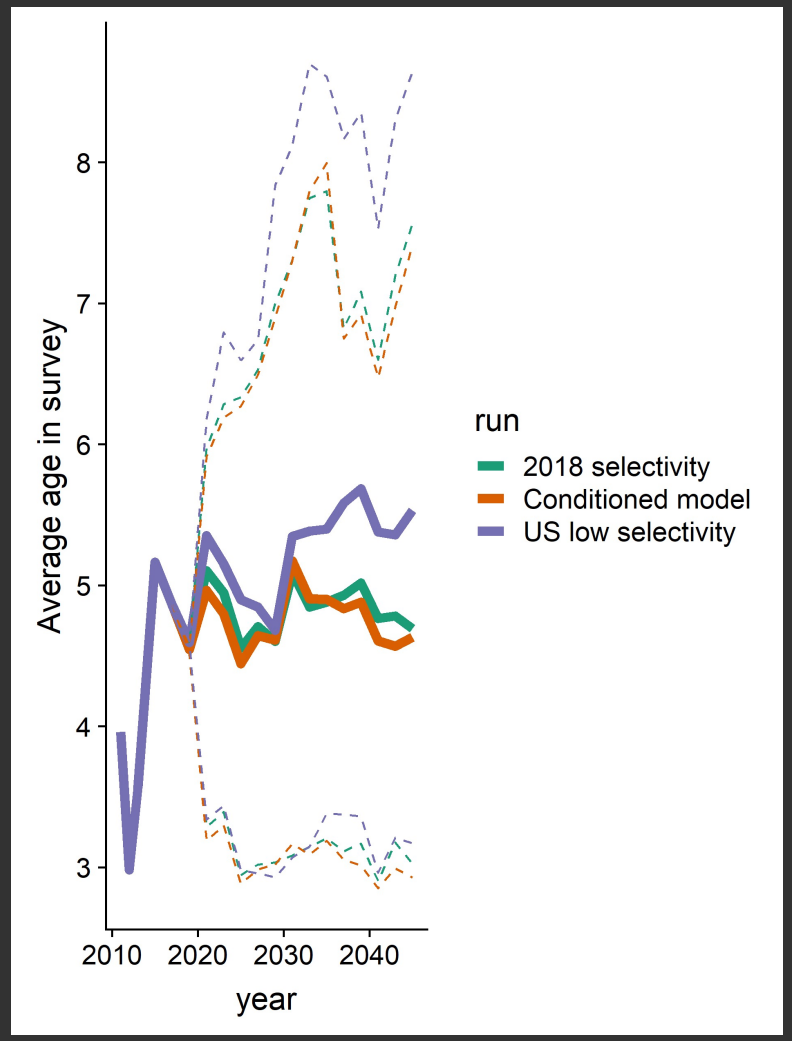
Age compositions



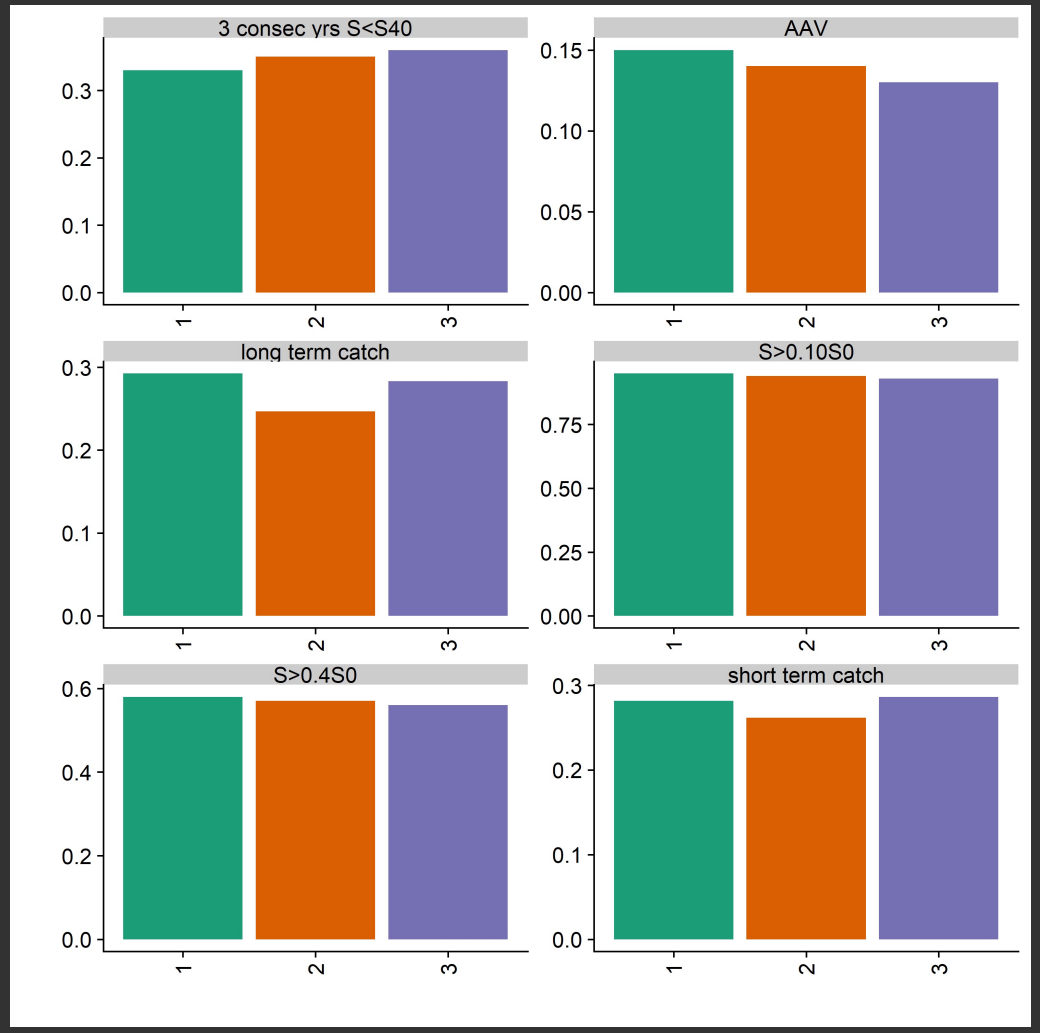


Average age in the stock





Performance metrics for selectivity scenarios



1) Conditioned model

2) US low selectivity

3) 2018 selectivity

Selectivity scenarios conclusions

- Targeting more small fish in the US does not cause major disruption to the stock
- When the fishery targets small fish in the US, a higher number of older fish move into Canada
- 2018 selectivity overall provides a worse outlook for the stock than the US targeting small fish

SURVEY FREQUENCY

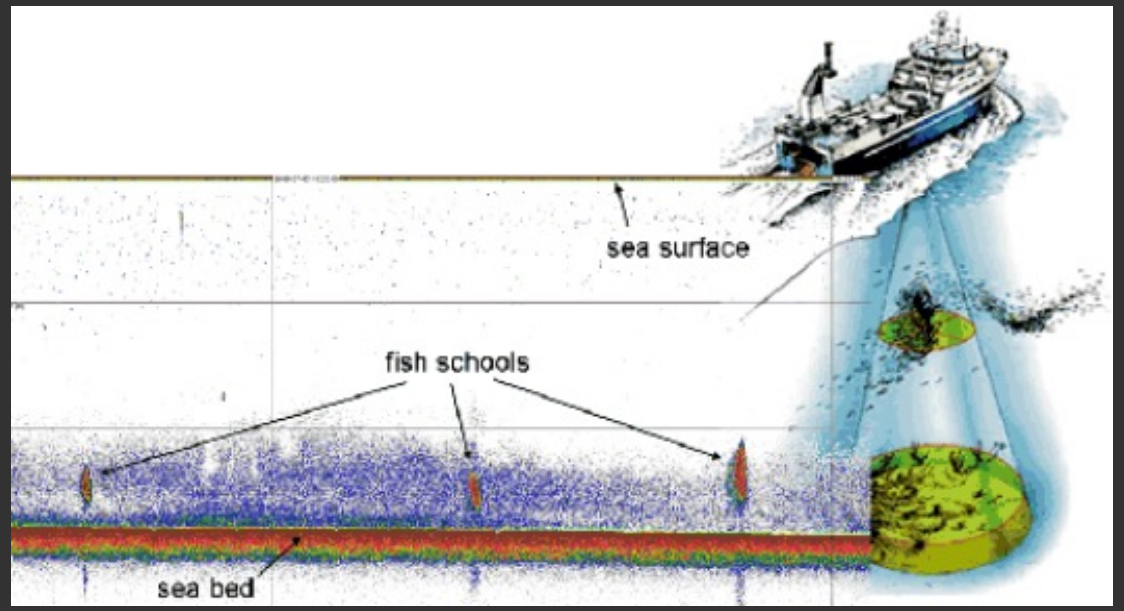
Survey frequency

- Three survey configurations

1. Survey every year

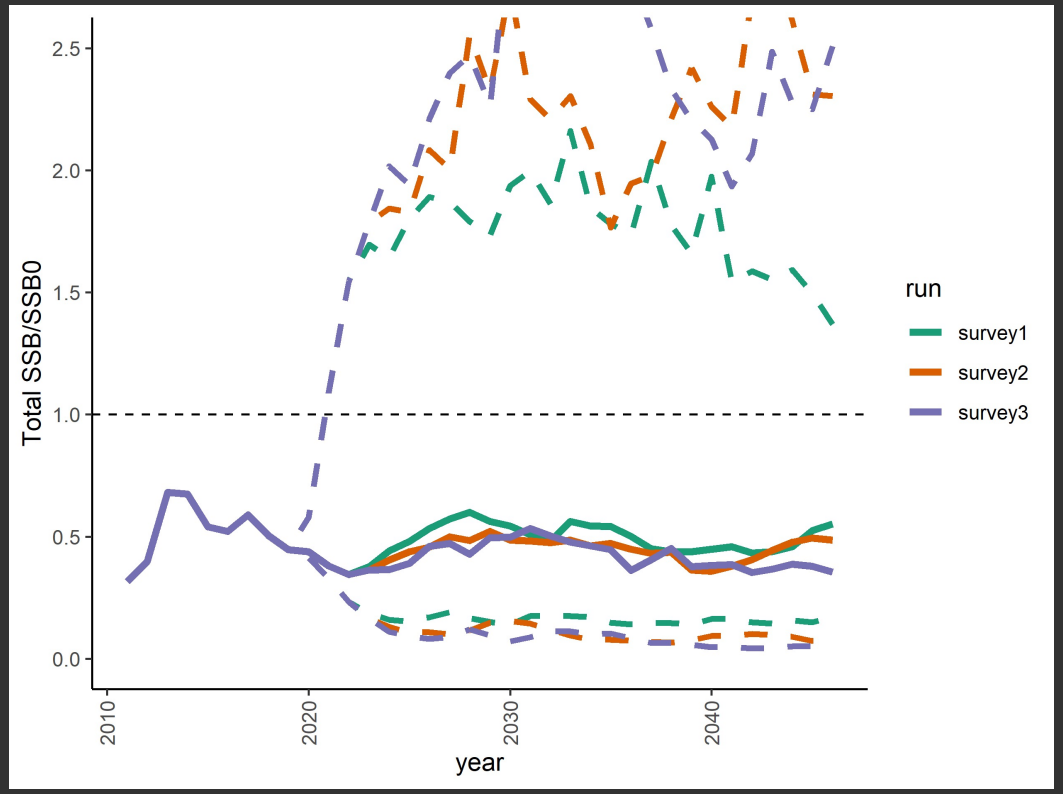
2. Survey every second year

3. Survey every third year



Survey measures biomass abundance, and age compositions.

Catch


Total SSB/SSB0
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survey1
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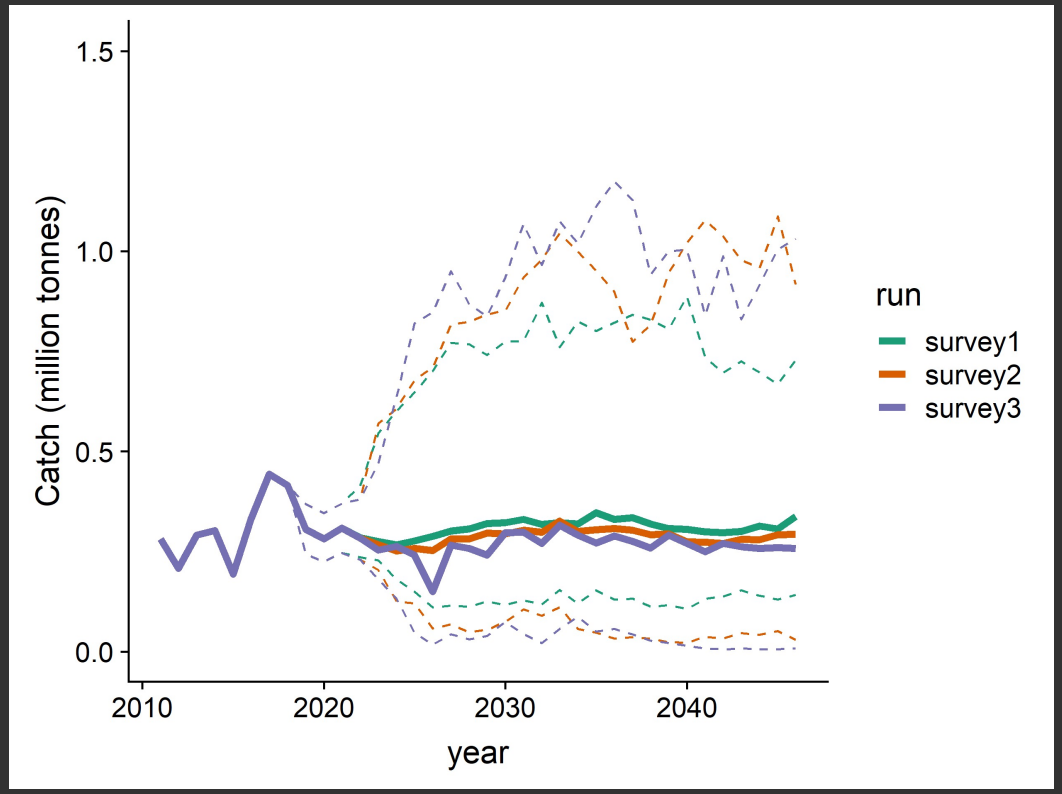
survey3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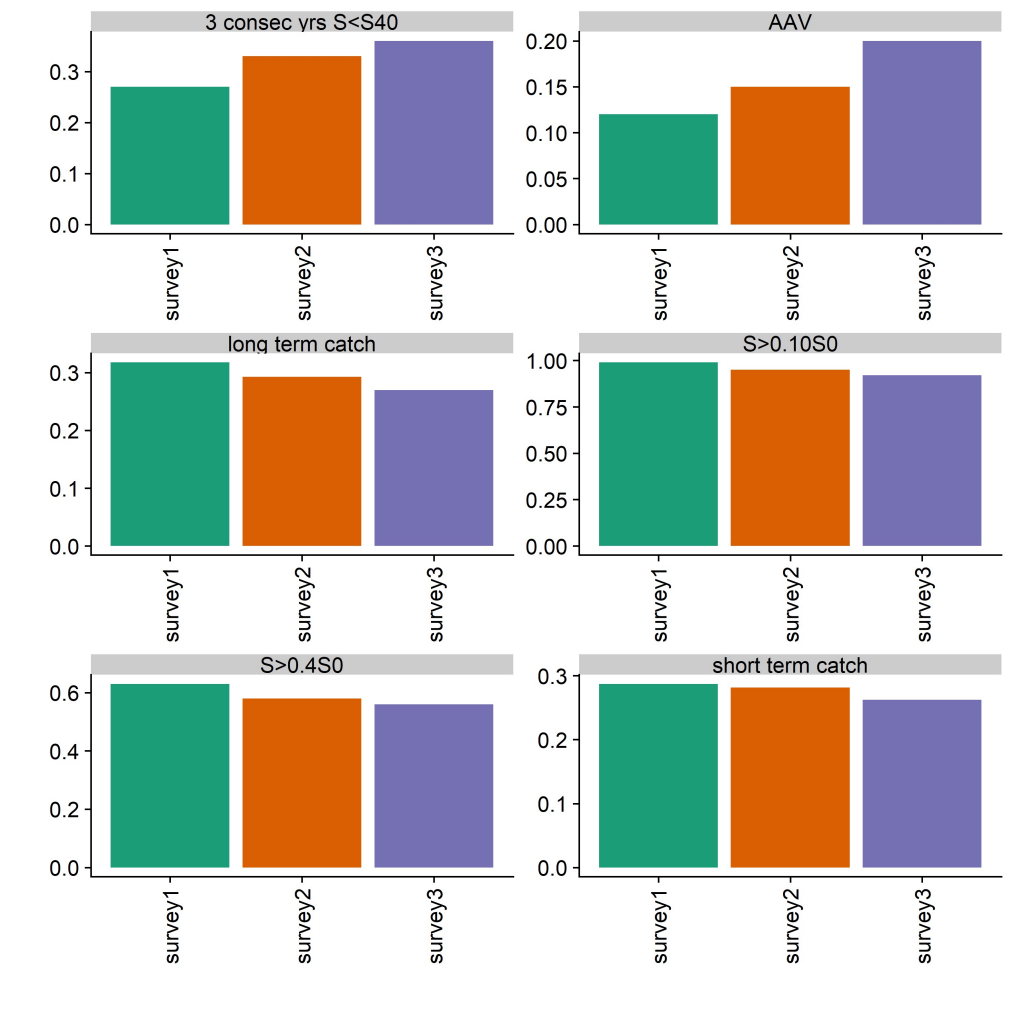
Performance metrics for survey scenarios



1) Annual survey

2) Biannual (baseline)

3) Triennial

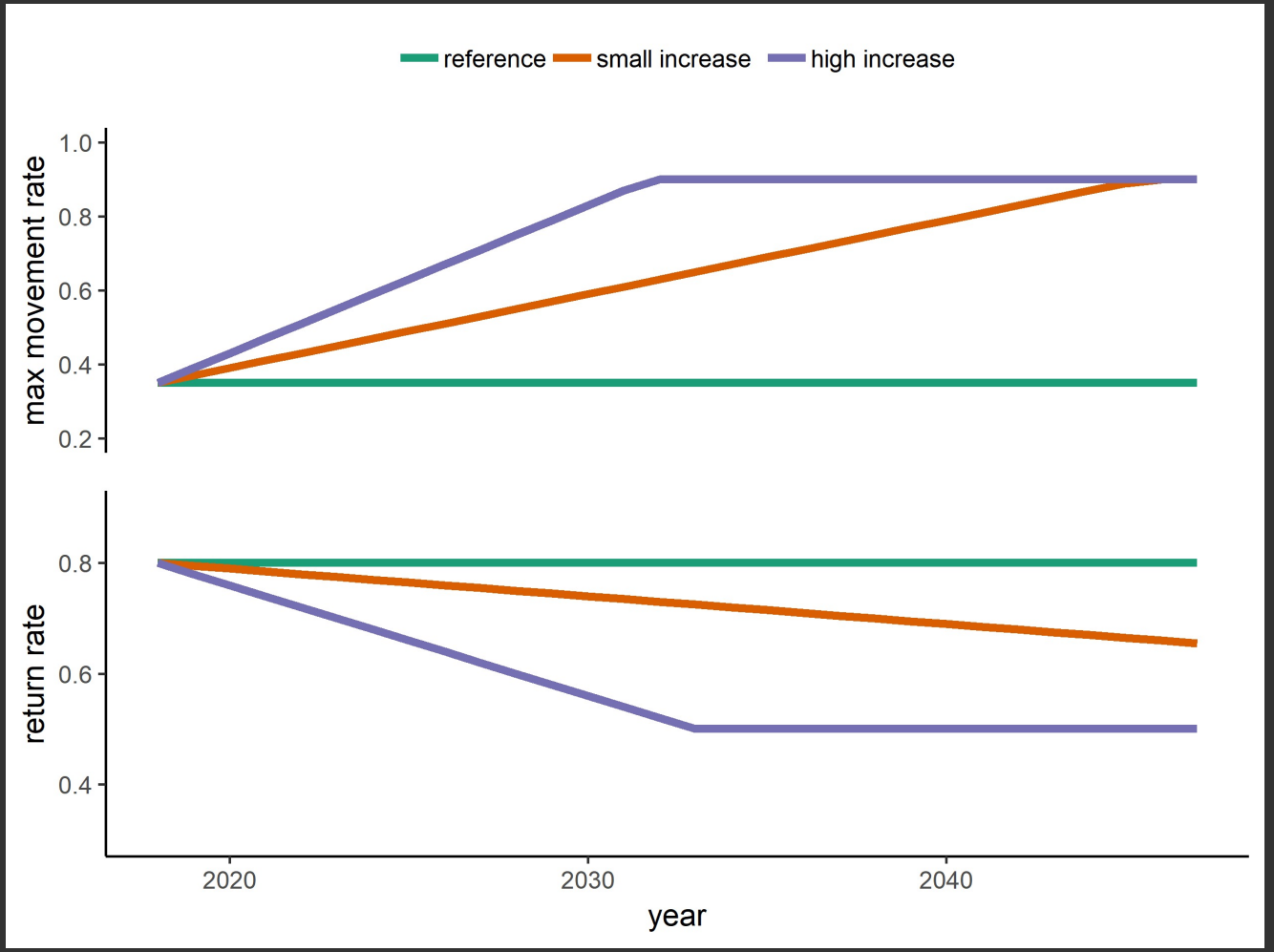
Survey scenarios conclusions

- More frequent surveys perform better than less frequent
- Having a survey only every third year increased the catch variability, and years with closed fishery.
- Total catches and spawning biomass were lower with less frequent surveys

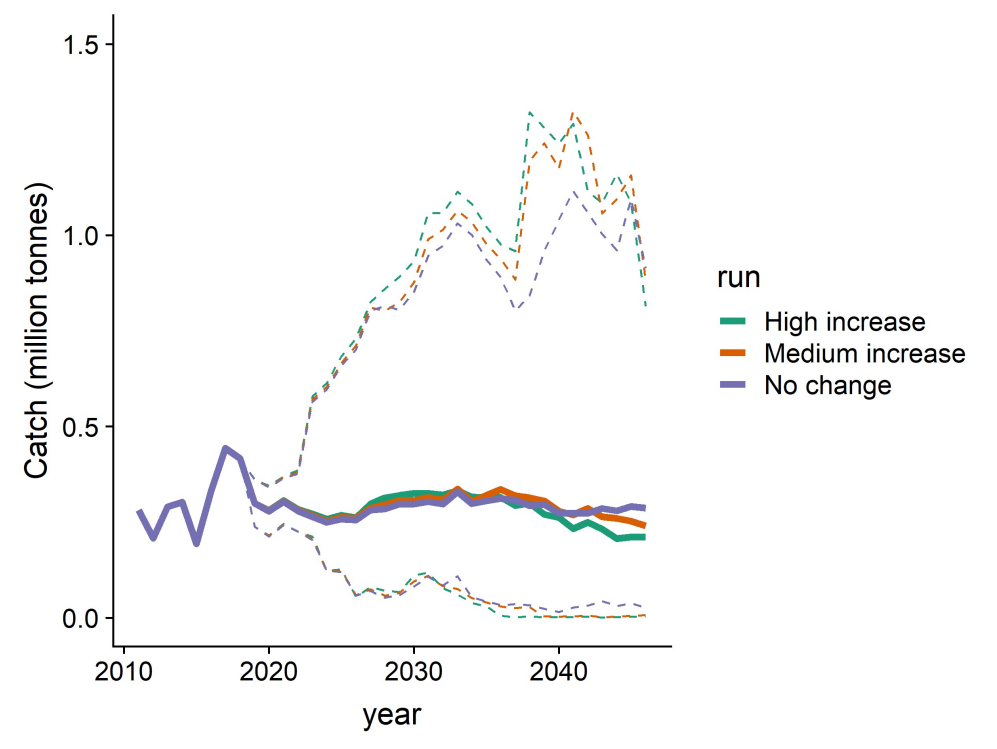
CLIMATE SCENARIOS

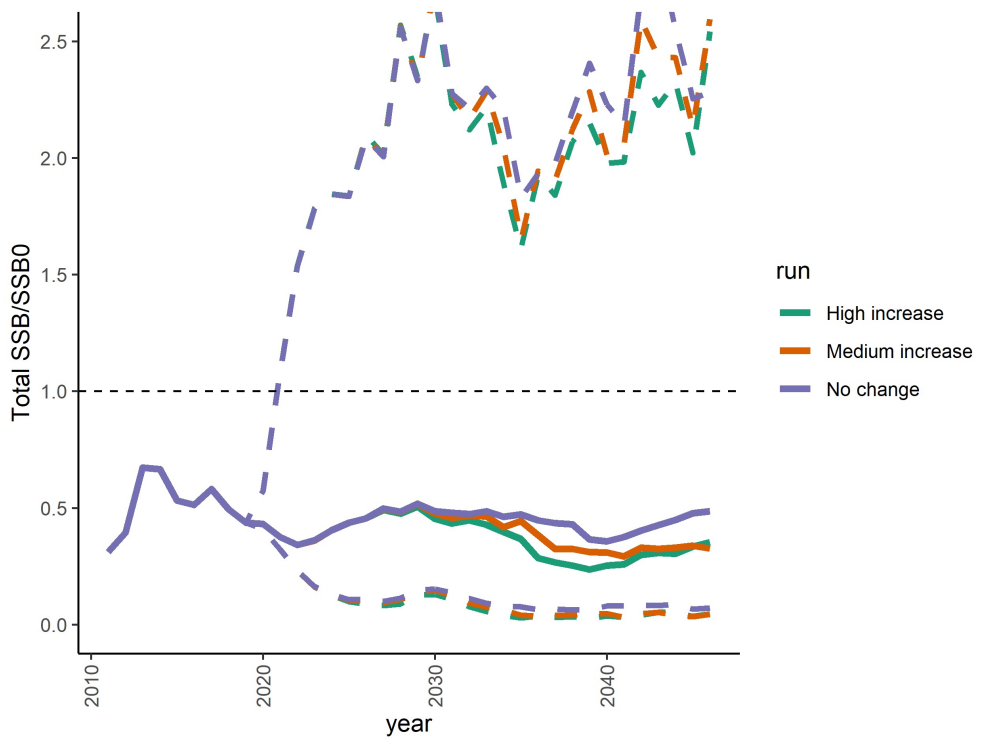
How climate change could affect movement?

- The maximum movement rate of fish increase over time
- The number of spawners returning south decreases

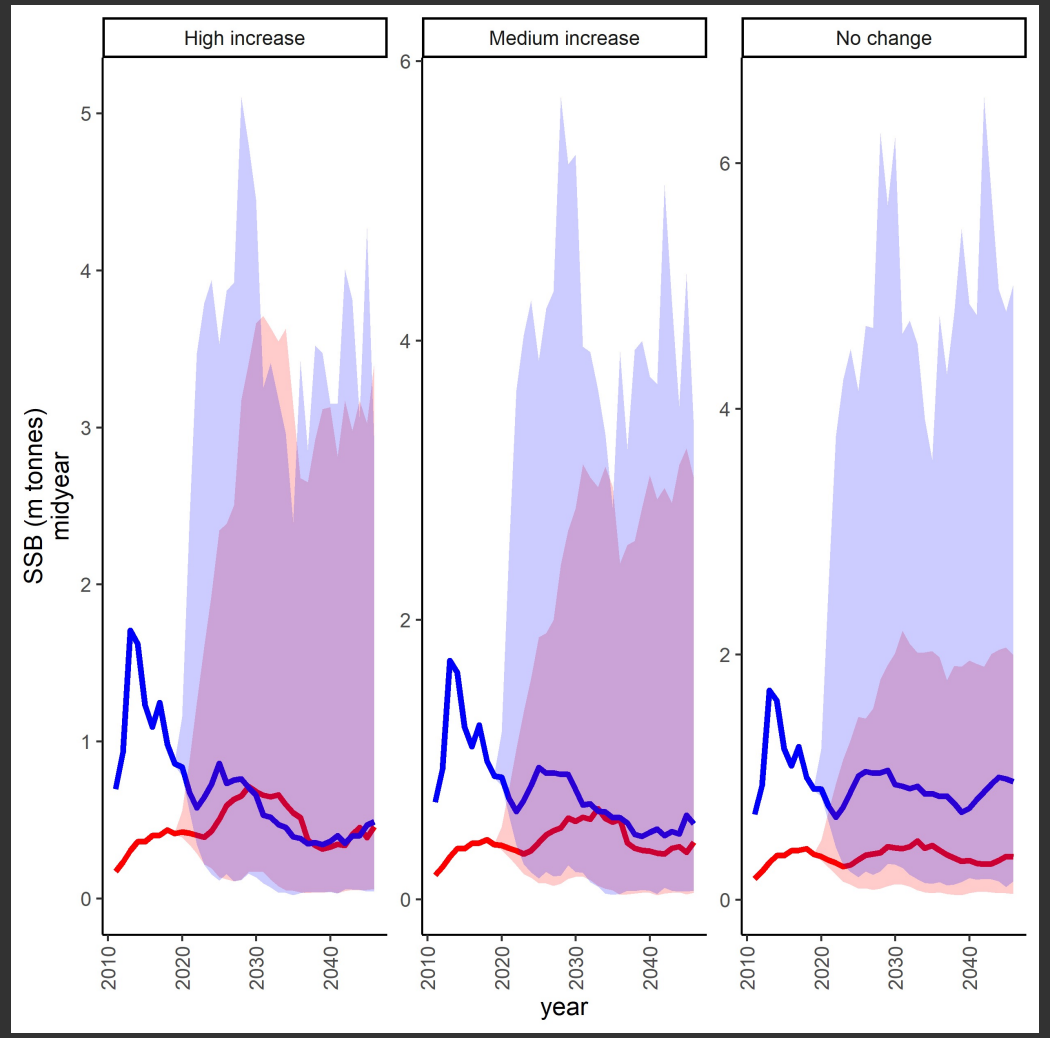


Climate scenarios





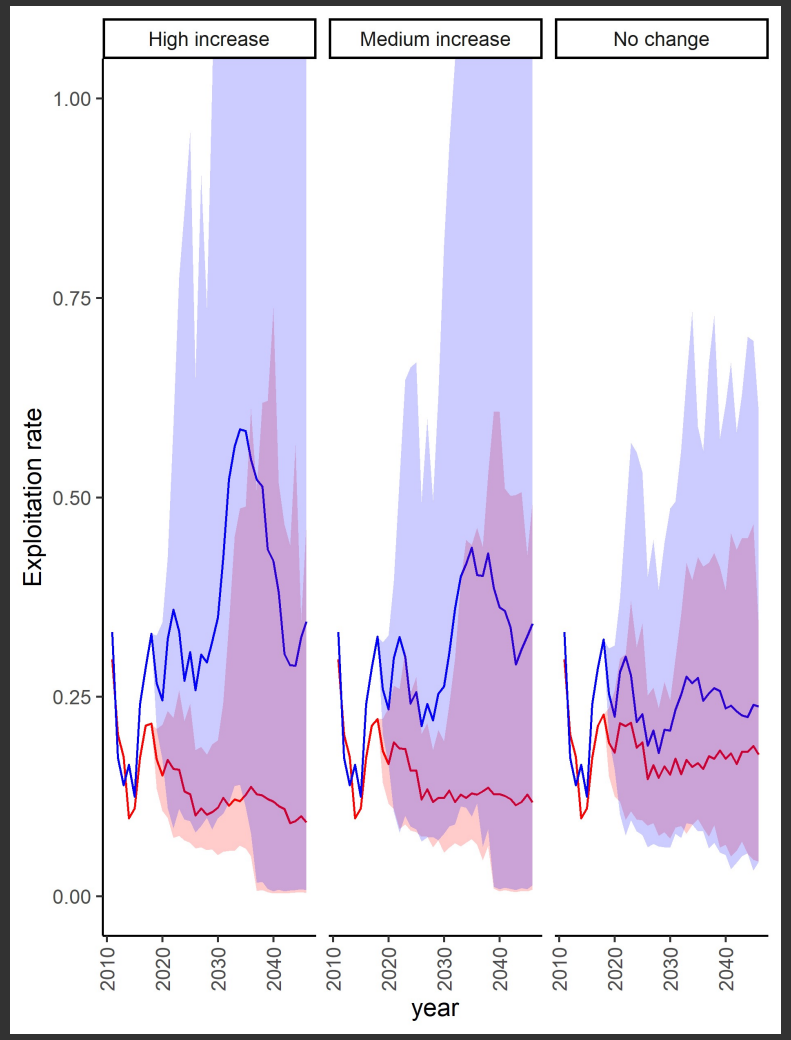
Spawning biomass distribution under climate change



Canada

USA

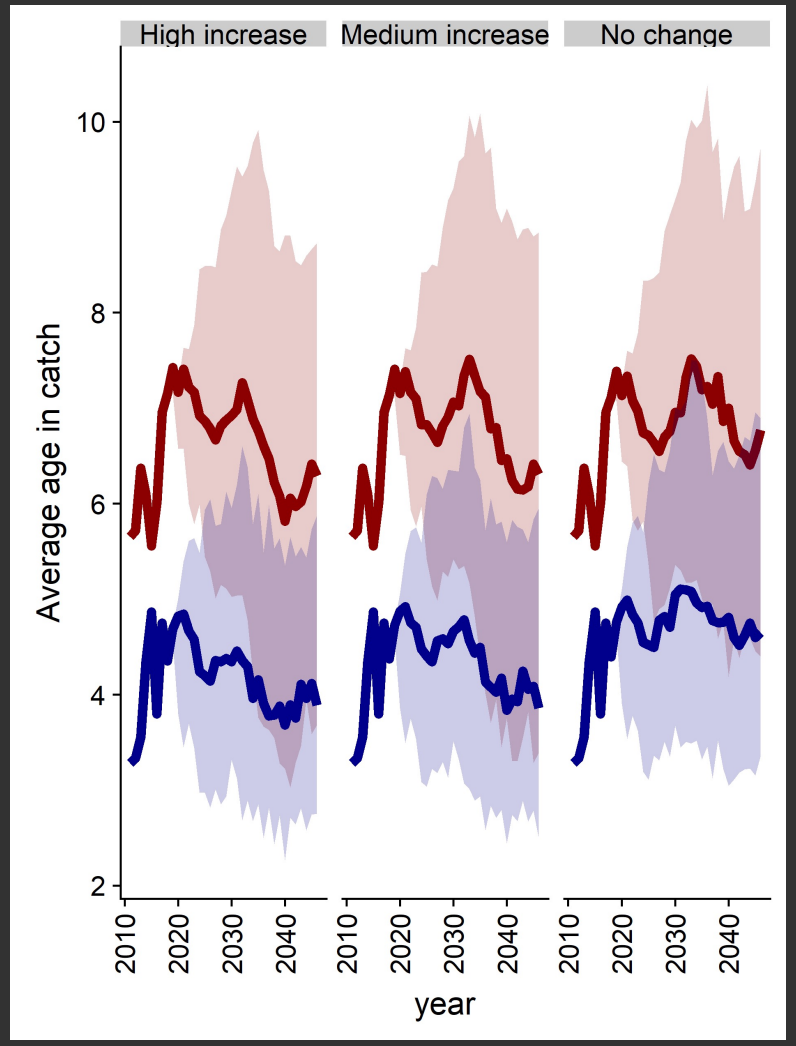
Fishing mortality under climate change

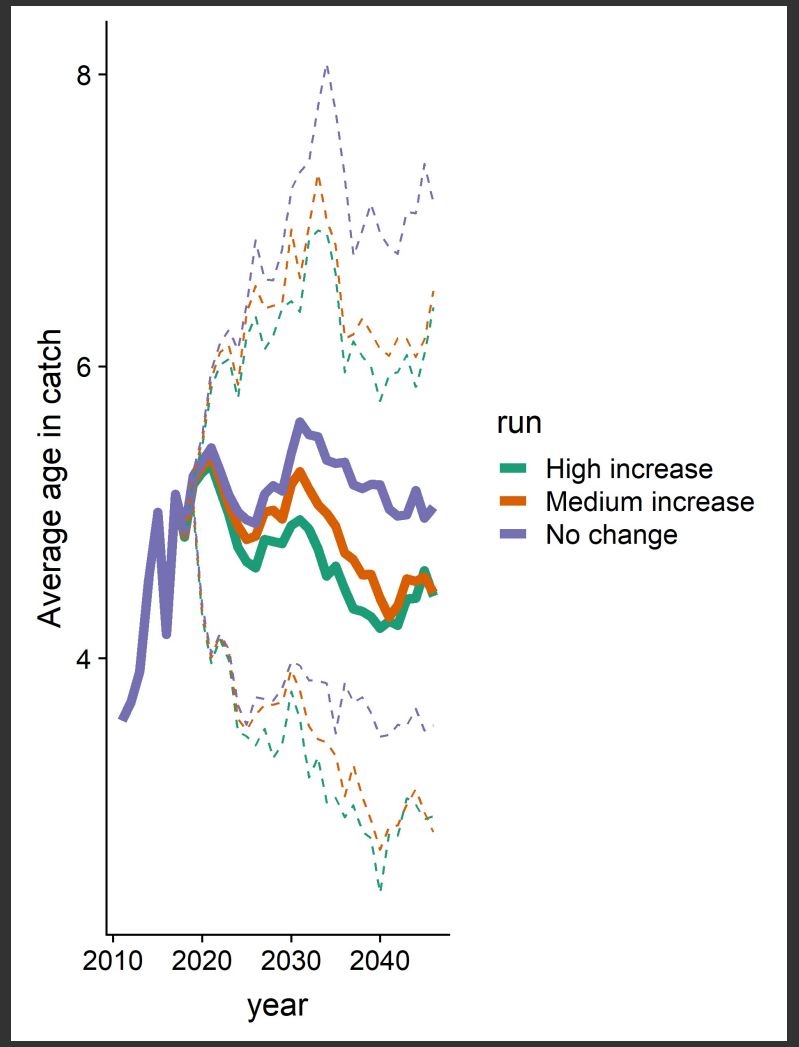


Canada

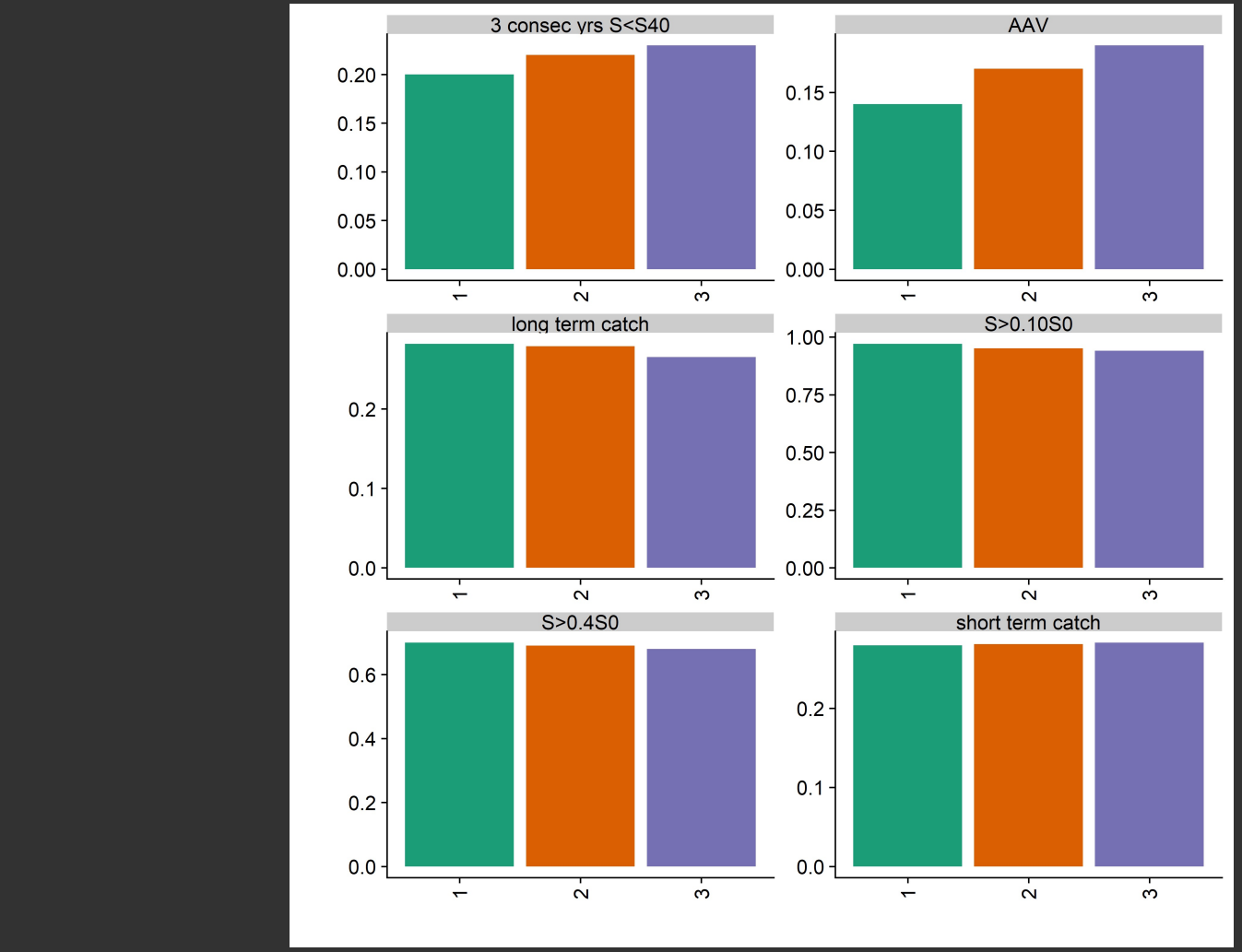
USA

Age compositions





Performance metrics for climate scenarios

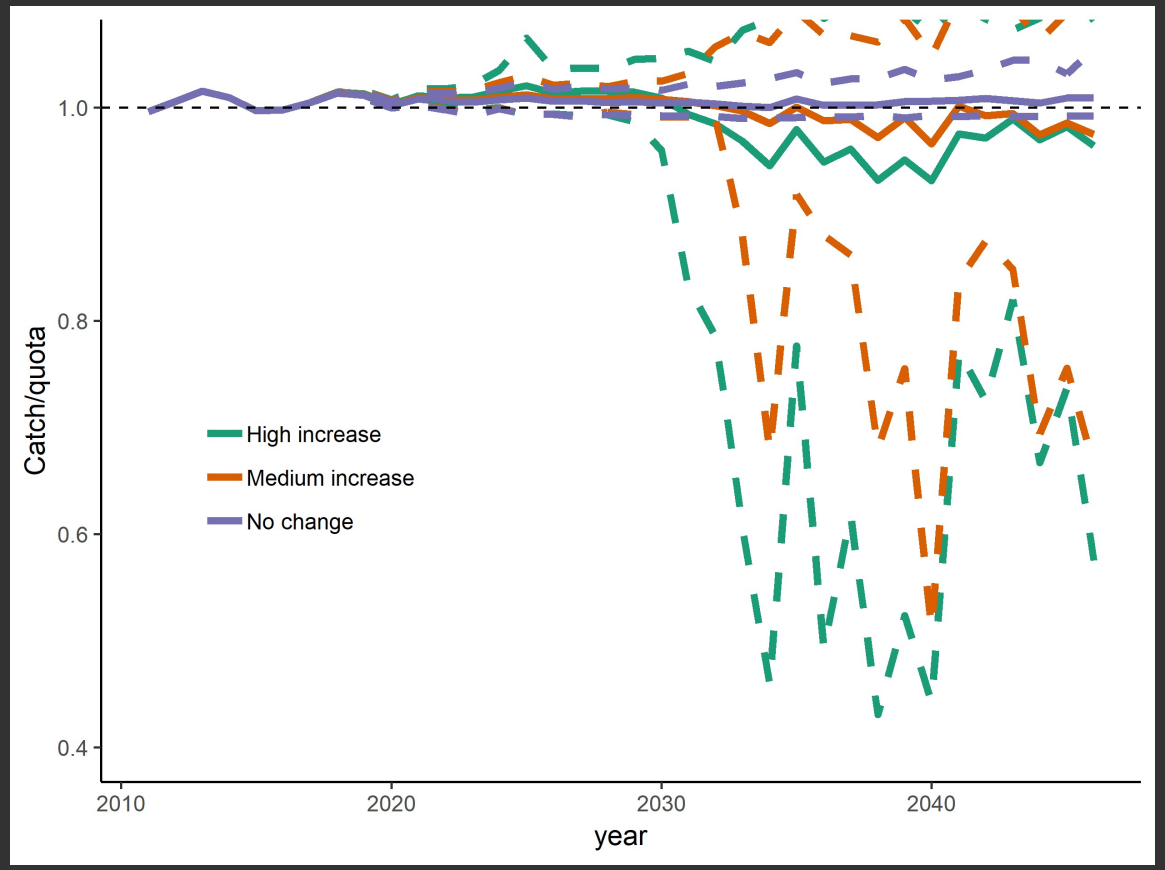


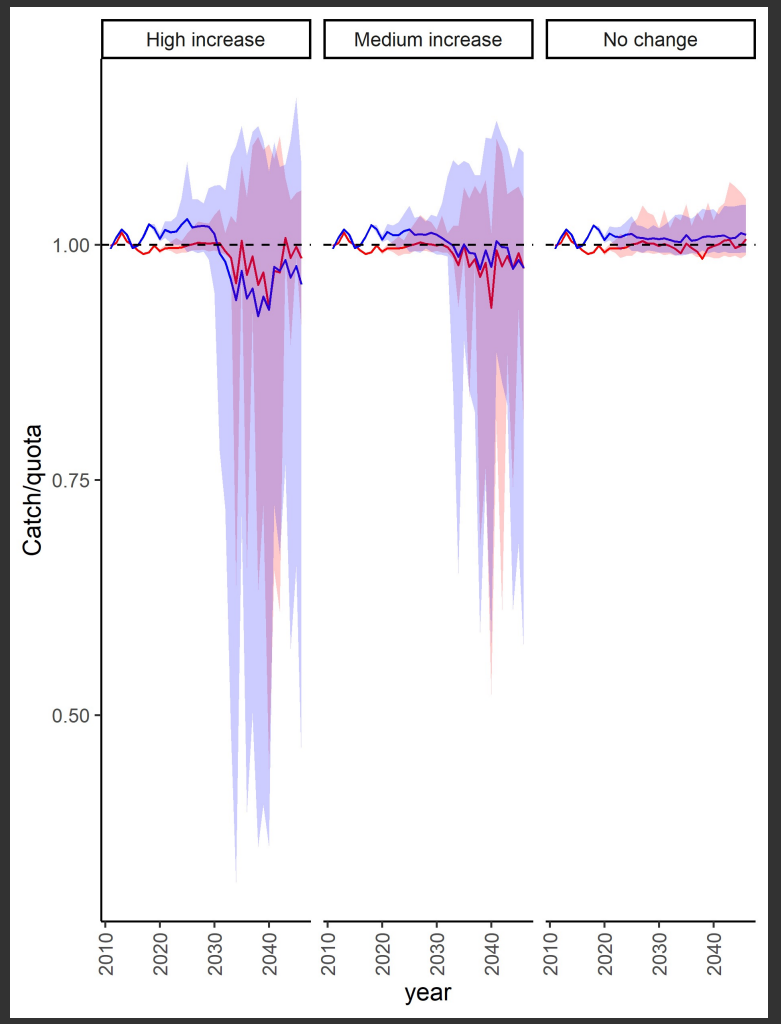
1) No change in movement rate

2) Moderately rate of change in movement

3) High rate of change in movement

Is the full catch potential realized?





Climate scenarios conclusions

- If climate change caused major northward distribution shifts in the stock, this could lead to more years with lower catches and closed fishery
- The US (to a lesser degree Canada) were more likely to not be able to meet their quota if climate change changes movement
- Catch variability also increased, and the US would require to increase their fishing mortality to meet their quota

Next steps and projects

- Short-term: Finish technical documentation, peer reviewed papers, and SRG review
- Future work:
  - Investigate how movement influences selectivity estimation (include time varying selectivity)
  - Time and spatially varying biological parameters

Overall conclusions

- The spatial structure has little impact on the coastwide management objectives
- If movement changes in the future it might influence movement
- Recruitment deviations are the primary drivers of uncertainty

Thank you

Review spatial objective and performance metrics for use in the Hake MSE

JMC meeting

Aug 2019

Kristin Marshall – NOAA NWFSC MSE Coordinator

On behalf of the MSE analyst team

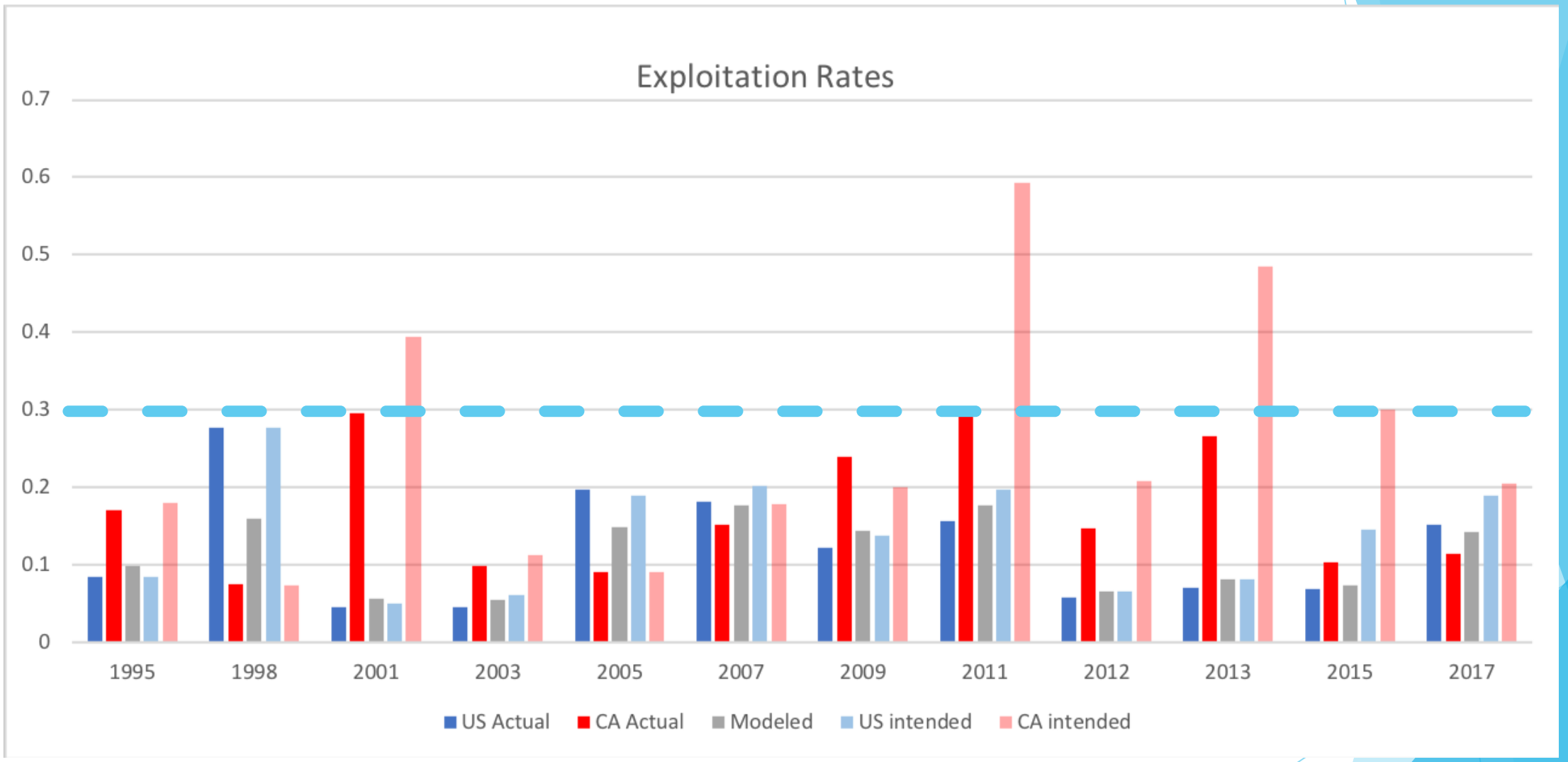
Defining spatially explicit performance metrics

Both parties can achieve their intended benefits under the treaty			
4a	Each country has the opportunity to attain their allocation of the TAC as specified in the treaty.	The exploitable (age 2+) biomass in Canadian waters during the fishing season is greater than the Canadian allocated TAC > 90 percent of years	$V_{CA} > 0.2612TAC/u_{CA}^*$ V_{CA}=age 2+ biomass in Canada u_{CA}^*= intended Canadian harvest rate
4b		The exploitable (age 2+) biomass in US waters during the fishing season is greater than the US allocated TAC > 90 percent of years	$V_{US} > 0.7388TAC/u_{US}^*$ V_{US}=age 2+ biomass in US u_{US}^*= intended US harvest rate

What is a plausible upper limit on exploitation rate? A starting place…

- Total catch or TAC by country
- Coastwide biomass estimate from assessment model
- Proportion of the acoustic survey biomass in each country in survey years

CA Catch (or TAC)/ (Coastwide biomass * CA proportion of survey biomass)


Exploitation Rates
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1995
1998
2001
2003
2005
2007
2009
2011
2012
2013
2015
2017
US Actual
CA Actual
Modeled
US intended
CA intended